Vol. XXVIII, No. 4 *Whole No. 240*

APRIL, 1928

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

TURTON & WARNER, *Publishers*
Publication Office: 404 N. WESLEY AVE., MOUNT MORRIS, ILLINOIS
Business Office: 2055 EAST 72ND PLACE, CHICAGO, ILLINOIS
Editorial Office: 7633 CALUMET AVE., CHICAGO, ILLINOIS

Published monthly, October to June, Inclusive, at Mount Morris, Illinois *Price, $2.50 Per Year; 35 Cents Per Copy*
Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

"Learning, undigested by thought, is labor lost; thought, unassisted by learning, is perilous."

—Confucius.

CONTENTS *for* APRIL, 1928

No Numbers Published for JULY, AUGUST AND SEPTEMBER

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

Published Monthly except July, August and September.

PRICE. The subscription price is Two Dollars and Fifty Cents a year; Canada $2.75; foreign countries $3.00; single copies 35 cents.

ALL REMITTANCES should be made payable to the order of **School Science and Mathematics. Remittances should be made by Post Office Money Order, Express Order, or Bank Draft.** If personal checks are sent, please add five cents for collection. Remit to **School Science and Mathematics, 2055 East 72nd Place Chicago.**

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXVIII No. 4 APRIL, 1928 WHOLE No. 240

THE PLIGHT OF COLLEGE PHYSICS.

BY JOHN G. FRAYNE,
Antioch College, Yellow Springs, Ohio.

Our Colleges and Universities have for some time been subjected to scathing criticisms from all sides. Most of this criticism has been of a general nature and without reference to any particular undesirable situation. The purpose of this article is to call attention to the low estate into which the teaching of a particular subject, physics, has fallen in most of our institutions of learning. As this subject is probably taught about as badly as any other it may be of some benefit to throw light on the present situation and offer some constructive suggestions for improvement. The remarks in this article are based largely on the experience of ten years of personal teaching in physics and on observation of similar efforts in other typical American institutions.

One does not have to look far for a cause for the present unsatisfactory teaching methods in college physics. The best physicists in our Colleges are so engrossed in research in the new physics that they pay little attention to teaching the undergraduate student. There has been practically no research in methods or technique for class-room or laboratory teaching. The general attitude has been one of indifference and even hostility to any interference with traditional procedure. The result is that in 1928 we are teaching physics very much as it was taught in 1900 while the subject matter in the meantime has been almost entirely rewritten. Besides, we have a far different student body today and the problems of education have multiplied enormously. Little has been done to acquaint

the non-technical student with the principles of the new and old physics, in spite of the marvelous advances of the past thirty years and the increasing applications of physics in everyday life. In order to understand the situation as it exists today, it is necessary to review the progress of physics in recent years.

In the late nineties the scientific world was set agog with new discoveries in physics. Following the discovery of Hertzian waves and X-rays, came the isolation of the electron and the discovery of the mysterious radiations from radium. An entirely new picture of the nature of matter was given to the world. A powerful searchlight was thrown on the nearly moribund subject and it began to glow in its newly found splendor. Soon came the quantum theory with its radical conceptions of the nature of radiation. The special theory of relativity and the various theories of atomic structure then followed in rapid succession.

As all these discoveries and theories originated in England or on the Continent, there began a pilgrimage of American students to Europe which kept up steadily until the outbreak of the war in 1914. These students returned to America greatly enthused over research in the new discoveries, and greatly influenced by the European methods of teaching. Up to this time American college teachers were loaded down with routine teaching and had little time for research but returning scholars demanded that they be given time and facilities for prosecuting research on a basis similar to their European brothers. That they were successful is attested by the rapid growth of graduate schools and scientific literature since 1900.

Research became a fad and a staff member who failed to fall in line soon became a persona non grata. Papers had to be ground out regularly or promotion to higher ranks was denied. Teaching ability was ignored in rewards of professorships and new men were chosen entirely on their standing as research men. The teachers were side-tracked to the smaller Colleges of the country where many of them laid the foundation of the careers of some of our most brilliant men in American Physics.

It should be stated at this point that such emphasis on research in American institutions has borne great fruit not only in producing much original work of a commendable nature, but also in giving a scholarly atmosphere to places where it had previously been rather nonexistent. I am inclined to believe, however, that we have overdone it and have committed

many sins in the name of research. It should also be made clear that I have no case to make against scholarly research. I am simply protesting against the lack of emphasis on the teaching of physics and the slipshod methods at present in common practice. Let us see what are the prevailing conditions today in the physics departments of some of our larger institutions.

In the introductory course, instruction is usually given in lectures, recitations, and laboratory periods. The lectures are usually given by the professors who are not the research men of the department. The recitations are ordinarily in the hands of assistant instructors or teaching fellows, while the laboratory sections are in the hands of the fellows and assistants. These latter groups of instructors are, as a rule, inexperienced graduate students. A standard text-book is nearly always closely followed, with very little outside reading. The laboratory experiments are described in a manual in such a manner that the student rarely has to use any imagination in performing them. He will usually find a long list of things not to do, lest he might, perchance, put the instrument out of adjustment. The experiments are almost without exception isolated pieces of work often consisting of the measurements of physical constants already well established which the student cannot possibly measure to any degree of accuracy in a few hours. The lectures, if well done, are the only things of interest in this course. The recitations are usually boring to all except a few of those of the lowest order of intelligence.

Efficiency is the watchword of the laboratory, and this means that the students are rushed through with the least possible effort on the part of the instructor. Very little exertion is made to improve teaching methods or deviate from traditional experiments. The result is the dreary, dull and uninteresting thing called college physics that is served up year after year to bored undergraduate students. One need only examine the records of any of our large institutions to see that less than one per cent of the students who study college physics become sufficiently interested to pursue advanced work in the subject. The others are frozen out by the mechanical instruction of men who regard their work as a very irksome task.

The great majority of those who pursue research work in our Universities are usually employed to give instruction to undergraduate and graduate students. They are given facilities

for carrying on research work of their own while they guide that of the graduate students in the department. Teaching is supposed to be their primary occupation and it is usually contended that research will improve their teaching. This latter statement cannot be accepted without some qualifications.

I have known many a research man of note to make a fizzle out of elementary teaching. This may be due to several causes. First, he may not be particularly interested in the task—in fact he may be very much bored by it. Secondly, he has probably had little training in the presentation of the subject matter and makes little effort to improve his methods. He fails to carry over any of his investigative ability into his teaching, and is content to teach as he was taught and do it indefinitely. His research abilities and experience seem to be inoperative outside his own specialty. Research does little to improve the teaching of such a man.

The placing of undue stress on research abilities in making academic promotions makes it evident to the graduate student that he must put all his energy into that field. Nobody pays any attention to his success as a teacher so he follows in the footsteps of his professors. He gets a Ph.D. degree and goes to a teaching position for which he is ill prepared. He may know the fine structure of a helium spectrum line to a nicety but he may be entirely ignorant of the problems of teaching. He may become marooned in some small institution where he has little contact with the men of his profession. In a few years he strikes a routine pace which he will continue to follow throughout his career. Except for meeting an occasional book agent he has little opportunity of learning what is going on in other institutions. He may attend an occasional meeting of the American Physical Society where he listens to technical papers on the minute details of researches on every conceivable aspect of modern physics. He goes home little wiser about physics and as ignorant as ever of the job for which he is being paid. The young Ph.D. who secures an appointment in a large institution will probably carry on research but often will not make any great advances in the art of pedagogy. His brother in the small institution is apt to do a better job of teaching in spite of inadequate equipment and small resources.

What can we do to ameliorate conditions in our physics departments so that teaching may be put on a higher plane and the subject given a place of prominence in the curriculum?

The author has a few constructive suggestions which he hopes may at least arouse discussion in the proper quarters. Teaching should be elevated to an honorable pursuit and placed on a par with research. This may be done in several ways. Teaching ability may be recognized and duly rewarded. This alone would encourage the younger members of the staff to give more serious attention to their teaching duties. Experimental methods may be adopted with a view to improving teaching. Test classes of carefully selected students may be instructed in different ways and results compared. Instruction with, and without, laboratory might be compared. The standard laboratory experiment might be displaced by a more interesting and instructive project type of investigation.

The possibilities for research into methods of classroom and laboratory teaching seem unlimited. Why not have some of our graduate students work out Masters' theses on some of these problems? They certainly should prove as valuable as a great many of the present dissertations on abstract problems which are little understood by the student. The thesis work for the Ph.D. degree should be reserved for a real investigation into the subject of physics. In this connection it might be pointed out that the graduate student would have an opportunity, at least in his Master's thesis, to choose between pedagogy and the present type of research work. He might "find himself" in the teaching field and become a successful instructor. How many of our Ph.D.'s are misfits as research men? The answer will be found in the number of such men who drop out of sight as soon as their thesis has been performed. Might not some of these men have done more for learning had they been trained in the art of teaching rather than in research, which they fail to follow up after graduation?

It will be a very difficult matter for isolated institutions to recognize the importance of teaching and put it on a par with research. There must be some central body of national significance to foster the idea and promote its growth. There is at present no institution in the country that is capable or desirous of doing this job. The American Physical Society is traditionally devoted to the encouragement of research in experimental and theoretical physics, and its meetings are devoted entirely to this laudable object. It has a committee on education which issues reports from time to time, but these reports seem to have had little significance in concentrating attention on the prob-

lems of teaching. Moreover they have not been discussed at any of the meetings of the society. A great many members of the society are not connected with educational institutions and it would not seem wise to bother them with the discussion of pedagogical questions.

It seems almost necessary that a new organization be founded for the express purpose of fostering teaching research in physics. Membership in such an organization should be limited to the faculties of Colleges and Universities with associate memberships open to any outside of these groups who were interested in undergraduate education. This organization should have regular meetings and should publish a bulletin of information to teachers of physics.

Nothing about this proposal is very original, as the American Chemical Society has a section devoted to chemical education and publishes a bulletin called the "Journal of Chemical Education." I am told that the meetings of this section are more largely attended and more enthusiastic than any other section. The Journal is a veritable mine of information to the teacher and publishes topics that would not be found elsewhere. One can see the effects of this organization on the teaching of chemistry. The new text-books are written mainly around the theme of the constitution of matter, and in them much of the information afforded by the new physics is to be found in very readable form. In fact, the chemistry student gets the impression that electrons and spectra are the peculiar property of chemists and that Moseley was an archpriest of the chemical cult.

It is difficult to estimate the gain to the entire group of physics teachers from an organization such as I have described above. We could have an interchange of ideas on all the vexing problems that arise in our work. Somebody, somewhere, will have just the idea that will settle some question that has given a lot of trouble. Among the many things that might be discussed, pro and con, would be the question of the preparation of students for post-graduate work in physics. The professor of physics, for example, at Oberlin might like to know what they are doing at Brown. The University of Iowa might like to know what standards of undergraduate preparation Cornell requires before admission to post-graduate standing. The scope of the general physics course would be another interesting topic for discussion. What emphasis should be placed on mechanics in a course designed for liberal arts students? What

elements of physics should be emphasised in a course intended for technical and engineering students? What is being done in the way of laboratory experiments? What is a reasonable number of experiments to expect of the student each semester? Is anybody conducting a research into laboratory experimentation, with a view to developing experiments that will arouse more of the student's interest and command more of his ingenuity? What would constitute a good ground work in physics as a preparation for industrial work? The representatives of the large industrial and government laboratories should be able to give some valuable advice on this point.

As soon as we begin to think about teaching as something that is vital we shall, no doubt, give attention to the problem of interesting the general public in the absorbing problems of physics. There is no better way to start this than to educate the rank and file of our institutions in the principles and aims of the subject. I do not believe that there is a course taught anywhere today that is designed to arouse the intelligent interest of students that will never use physics as a tool in their life work. It is true that there are courses designed for liberal arts students, but these are usually diluted courses that have no fundamental difference of approach from the orthodox course. I believe that the development of a course of this kind is one of the most important problems that faces us today. We have a duty to perform in educating the public as well as the technical student, and I am confident that our standards will not be lowered one whit by so doing. Physicists now are rather secure from the depredations of anti-evolutionists and others of their ilk but with the advance of physics who can predict when we may encounter opposition from a misguided public? Now is the time to forestall such a catastrophe or we may regret losing a golden opportunity.

We have all heard rumblings within and without our departments that all is not well with our type of instruction. We all know that physics is the most unpopular course on the campus and we all have the same explanation to offer. And of course we are always correct! Those of us who are aware that our instruction is far from perfect, whether we be research men or just pedagogues, will surely welcome any honest effort to help us do a better job. Good teaching will surely redound to the benefit of research! It seems that we ought to be able to remedy a situation like that in a large Mid-western University where

less than one per cent of those who take the general course pursue any form of graduate work in physics. It is significant that a small Wisconsin College with an enrollment of 400 students drawn from a small radius should send more students to graduate schools of physics than a neighboring university with nearly 11,000 enrollment. Situations like this demand serious attention of all physicists who love their calling. They will surely agree that something ought to be done and done right soon.

Let us shake off the shackles of tradition and strive to put physics in its rightful place on the campus and in everyday life so that this great body of learning may continue to grow apace, aided and abetted by an intelligent and zealous body of teachers who have the research spirit and research men who are primarily great teachers.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

The Monthly Message

Progress among Members. The long roll of members in our last Year Book suggests that a number of these are leaders who publish books, carry on research, appear on the public platform, receive marks of distinction, or accomplish similar achievements of interest and value to other members. Reports of such attainments or of marked promotions will be read with satisfaction; send in the good news of success that it may become a message of inspiration for others in the Association.

The General Science Section. The officers of this section for 1928 are:

J. O. FRANK, Chairman
State Teachers College
Oshkosh, Wisconsin

HARVEY F. JOHNSON, Vice-Chairman
Proviso High School
Maywood, Ill.

C. L. THIELE, Secretary
Assistant Director of Exact Sciences
Board of Education
Detroit, Mich.

The chairman is at present busily laying out the program for next Fall. Send in your suggestions.

On our membership list are found the names of 9 authors of General Science Texts and 7 authors of General Science Tests or of texts on The Teaching of General Science.

W. F. ROECKER, President,
Boys' Technical High School, Milwaukee, Wisconsin.

A CONTRIBUTION TO THE TEACHING TECHNIQUE IN THE SECONDARY SCHOOLS.

By J. S. Georges,

University High School, Chicago.

Presentation is the second step in the teaching cycle and along with the first, exploration, seeks to establish motivation for the principles which are to be studied in the new unit by connecting up with the processes and principles already in the possession of the class. In it the teacher presents the important concepts of the unit in the form of a connected discourse. As Professor Morrison puts it[1], "this step is the teacher's supreme opportunity for effective direct teaching."

Effective presentation depends upon three factors: (1) control technique as determined by the attention of the class and their ability to listen effectively, (2) the presentation discourse, its length and the amount of preparation back of it, (3) the teacher, his personality, his knowledge of the subject, and his ability as a speaker. For a full discussion of the subject the reader is referred to Professor Morrison's book, quoted above, and Professor Breslich's article in University of Illinois Bulletin, Vol. XXIII (March, 1926), No. 27, pp. 167-175. We are concerned here only with the second factor, namely, the presentation discourse, its preparation and length.

If presentation offers a splendid opportunity for effective direct teaching then the teacher must be well prepared to present a connected discourse that will in a few minutes put across the principal ideas of the unit. An ordinary talk delivered on the spur of the moment without preparation and poorly organized will not do to "sell" the subject to the class. The important concepts of the unit must be not only recognized by the teacher but their inter-relations as well as their relations to the unit must be emphasized in his presentation. Preferably the teacher should first prepare a well organized paper, familiarize himself with its contents, and then use it as a basis of his talk.

The attitude of the class in a large measure determines the effectiveness of the presentation. Even though the group control of the class may be very good the attention of the class cannot be held for a long time. Young people cannot listen with close attention to long speeches. Ten or fifteen minutes should be adequate for a presentation on any unit in the secondary school subjects.

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[1]Henry C. Morrison, *The Practice of Teaching in the Secondary Schools*, p. 226.

The following presentation was prepared by the writer and used in his own classes. It is reproduced here with the hope that it may be of benefit to teachers using the Morrisonian technique.

A Model Presentation Paper on Representation of Numerical Facts by Line Segments.

(Unit I, Junior Mathematics I)

Our work in mathematics consists mainly of the study of objects, their sizes, shapes, properties, and any quantitative relations between them that we are able to determine either through observation and measurement or through the process of reasoning. In order to carry out our study more effectively and economically we have developed certain ways of representing quantities and numerical facts. Thus in Arithmetic you were shown how certain symbols represented things, and how convenient it is to work with the representative symbols instead of the things themselves.

Let us recall for a moment this type of representation in order to understand and fully appreciate the new type of representation which we are going to study in this unit. Suppose we think of a group of objects, such as eggs. Here we have five eggs in this group ooooo, and three in this one ooo. If we wish to put the two groups together, either we put the five eggs with the three, or else the three eggs with the five, and we now have only one group oooooooo containing eight eggs. In this operation we work altogether with the things themselves, and that is the way you first studied mathematics, working with objects. But you soon discovered that this method is laborious, slow, and inconvenient to use, especially if the groups are too large; and you were led to use symbols to represent objects. You worked with these symbols and interpreted your operations in terms of the objects which the symbols represented. You wrote the symbol 5 for the first group, and the symbol 3 for the second group, and combined these symbols by an operation called addition to get a new symbol to represent the whole group. Symbolically, $3+5=8$. But this method and the symbols apply to all other objects as well. In fact they can represent any numerical quantity, as long as we can count or estimate the number of objects in a group.

Now by the new method of representation, which we shall learn in this unit, we shall let a line segment five units long |_|_|_|_|_| represent the first group, and a line three units long |_|_|_| the second group, and we put the two line segments together obtaining a line segment eight units in length |_|_|_|_|_|_|_|_| which shall stand for the third group. What have we done here? Why, we have not only let straight line segments represent objects, but we have actually added these new elements just as we were able to add the arithmetical symbols. And that is what we are going to do in this unit, add and subtract line segments.

We might point out the advantage of this method over the old arithmetical method. Suppose we wish to represent the heights of the pupils in this class. Of course by the old method we would write the symbol or symbols which represent the height of each pupil after that pupil's name. Thus, John Brown, 5 ft., 2 in. Whereas, by the new method the work would look something like this:

John Brown————————
Mary Jones——————
Henry Smith——————————
etc.

Now let us see why this new method is more advantageous to use. Suppose we wish to find the tallest pupil in this class. By the old method we would have to examine the whole list carefully and find the number that represented the greatest height. We must not overlook a name. While by the new method the eye catches at once the longest line, and the work of finding the tallest pupil is very simple.

You have doubtless seen such sequence of lines in newspapers and

magazines, either placed horizontally or vertically. They are called bar graphs, and they represent numerical facts for the purpose of comparison. In this unit we shall learn also to make and interpret such graphs.

But if we are going to work with these new elements, straight line segments, we must find out what they are, what properties they have, and how to handle them, that is, how to perform the desired operations upon them.

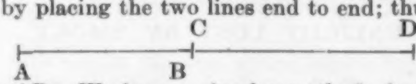
You note that the term straight line segment means in the first place that we have a straight line, with emphasis on the adjective straight; and in the second place we have a segment or portion of that straight line. You will learn that a straight line may be ever so long. Thus, this straight line ——————— could be produced in either direction as far as the edge of this sheet (Blackboard.) If we had a larger sheet of paper, the line could be made still longer. The important thing to remember is that if we are to work with such straight lines signifying directions, we must know their magnitudes or lengths. That means that we will have to be able not only to draw a straight line, but to measure it.

In this unit you will learn to use three different methods of measuring line segments. The first, which perhaps most of you already know, is the ruler method. Your ruler is graduated on one side in inches and fractions of an inch, and on the other side in centimeters and millimeters. So we decide whether we wish to measure our line segment in inches or centimeters and see what part of the ruler the line segment covers by placing the ruler along the line. Now after measuring the line we must put down our result in a statement. We could say "this line is 3.5 cm." But such a method of talking about lines is n[illegible]effective than saying "this boy, or that girl." The best method is [illegible] the boy or girl and not to point at them. Similarly, we give the [illegible]ment a name, or as we say in mathematics, we designate or label it. We let capital letters indicate the end points of the segment and write AB for A |———————| B. Of course we could use any other letters. This idea is not altogether new for we use letters to designate people. Thus, J. S. G. stands for me to those who know me. With this understanding then, we write the result of our measurement thus: AB = 3.5 cm.

The second way of measuring line segments is with ruler and compass. By this method, which is fully explained and illustrated in the text, we transfer a line segment from a position where it would be inconvenient to measure it with a ruler to a more suitable position. To do that we simply open our compass the length of the segment and place the points of the compass on the ruler and see how many divisions there are between them. That is the length of the line segment.

The third method, which will be fully explained to you later on, is by means of the compass and a special kind of paper called squared paper. For graph-work this method is the best.

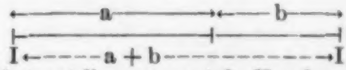
It was stated above that we shall learn to add and subtract line segments. If we have two line segments A |————| B and C |————| D, we could find their sum by placing the end point C on B, that is by placing the two lines end to end; thus,



Then AB + CD = AD. We have a simpler method of stating this result. We use small letters for the lengths of line segments. Thus we have

a ——————— and b ———— . By measuring these line segments

we can find the values of a and b. Suppose a = 4.5 cm., and b = 5.3 cm.; then a + b = 4.5 + 5.3 cm. The operation would look like this diagrammatically,



How would we substract line segments? You know that the operation of subtraction is doing opposite to what you do in addition. So in sub-

traction instead of spreading out the line segments you make them overlap. Thus,

a
|———————————|
I←–a–b→←b––→I

These are interesting operations, and though now they may seem difficult, in fact they are very simple. They will be explained with much detail when we take them up later.

In this unit we shall also learn to divide a line segment a by another line segment b and express this ratio by writing $\frac{a}{b}$. To find the value of the ratio you could measure the line segments a and b, then you would have a familiar arithmetical ratio, or fraction. If the measures of a and b are 6 cm., and 9 cm. respectively, then $\frac{a}{b}=\frac{6}{9}=\frac{2}{3}$, a well known ratio.

We will not slight the operation of multiplication either, for we shall find the product of line segments a and b, and write ab to mean a times b. However, we will interpret the actual meaning of this product in another unit.

Let us once more recall the important things we are going to do in this unit:

1. Learn what a line segment means.
2. Designate a line segment by two methods.
3. Measure a line segment by three different methods.
   a. The ruler method.
   b. The ruler and compass method.
   c. The compass and squared paper method.
4. Operate upon line segments with the four fundamental operations.
5. Compare several line segments by means of the graph.

So you see that these new mathematical elements obey all the laws of arithmetic which you have studied, and you will have much fun working with them. More than that, they will ever be ready to serve you when you wish to apply the mathematical principles you are learning to practical problems. But they will have to be handled carefully and in the right way. That is exactly why we are studying this unit. Let me introduce you then to the study of line segments by asking you to read carefully pages 1-17 of your text, and to do all the exercises you find in those pages.

(Note: This is the first part of the unit, taking up the meaning, designation, and measurement of line segments with ruler, and finding their arithmetical average. The work is done in the classroom. Each pupil working individually, at his own rate, and under the supervision of the instructor.)

SUNLIGHT LOST BY SMOKE.

Manhattan's great smoke screen cuts out 42 per cent of the morning sunlight that is every Gothamite's just due on winter days. At noon the loss is 18 per cent. The figures for this indictment of the smoke nuisance in large cities have been compiled by experts of the U. S. Public Health Service. Loss of efficiency from decreased lighting is not the only result of excessive smoke in manufacturing centers, they maintain. It also cuts out to an appreciable extent the ultra-violet rays necessary for good health.

The importance of getting rid of smoke is emphasized for the preservation of eyesight and health generally, as well as prevention of accidents. On foggy days the loss of light runs even higher than the figures quoted, it was stated.—*Science News-Letter.*

THE PARA RUBBER TREE IN THE AMAZON VALLEY.

By Carl D. La Rue,
Department of Botany, University of Michigan,
Formerly Specialist in Rubber Investigations in Charge of the Amazon Rubber Expedition, Bureau of Plant Industry, U. S. Department of Agriculture.

Although for some time the United States has been the largest consumer of rubber in the world, it is only recently that the American public has been interested in the production of this important raw material. The Stevenson Act was intended to increase the price of rubber by restricting the output of the plantations, and was sufficiently successful to emphasize our dependence on foreign supplies. This led to a fear that at some time we might be hampered seriously by the rubber monopoly held by the British, and much discussion was devoted to the problem. As an ultimate result of the agitation Congress appropriated funds for a study of the situation with the idea of determining the possibilities of the cultivation of rubber in regions not subject to the British restrictions, and possibly nearer the United States than the most of the present producing areas.

The United States Department of Agriculture took a part in these studies and the writer was employed by that organization to conduct an expedition to the Amazon Valley to investigate both the collection of the wild rubber as carried on there, and the possibility of developing successful plantations in that region.

Since the most of the South American rubber, as well as the highest quality of that rubber, comes from the south bank of the Amazon, the party devoted its attention almost entirely to the southern tributaries of that stream. The writer had an opportunity to visit the Xingu, the Tapajos, the Madeira, the Beni, the Mamore, the Madre de Dios, the Purus, the Acre, and various tributaries of these streams. From all these, and many other rivers, rubber is being collected continuously, the amount secured being dependent to some extent on the market price of rubber.

In general the rubber collecting industry is in a state of demoralization due to the low prices which have long prevailed. Not since plantation rubber began to be marketed in quantity has the collection of wild rubber been profitable, and few of the workers make more than a lean living from their efforts. This condition must continue indefinitely except for brief

periods when a higher price level is reached. It seems inevitable that the collection of wild rubber on any considerable scale must cease before very long.

There are two reasons for this pessimistic prediction. One is that the trees are scattered in the forest so that there are rarely more than a few trees to the acre and a great amount of time is spent in passing from tree to tree in the daily round of collecting the milky juice, called *latex*, from the trees. Another reason is that the greater part of the existing trees lie far up the rivers, and often far back from the rivers on the ridges, so that transportation to market is a very serious item. Practically all the trees on the lower rivers have been tapped to death and the *seringueros*, or rubber cutters, have to go farther afield every year to find suitable collecting fields.

The method of securing the rubber is primitive and has undergone few changes since the beginning. The *seringuero* selects a suitable base of operations, usually on land owned or leased by a *patron* who advances supplies to the *seringuero* and charges them against the season's crop. It frequently happens, however, that the *seringuero* works on government land on which he is merely a squatter, and where he counts on the vast expanses of territory to insure escape of detection. In many cases he is ignorant of the true condition and believes the land to be rightfully under control of the patron who is the dishonest party. Many cases have been found by the writer where individuals obtained rubber from large areas of government land to which he has no possible right other than that of might in a local district, where none dare dispute his claim.

When he has built himself a crude palm thatched hut the rubber cutter is ready to begin operations. He explores the woods for rubber trees and connects those found by a trail, bridging the streams with poles or logs. Such a series of trees connected by a trail is called an *estrada*. The number of trees in an *estrada* varies with the distance from tree to tree, and on the energy and industry of the *seringuero*. Some *estradas* have as few as 50 or 60 trees, others may have 400 but the latter number can be tapped in one day only if they stand rather close together and if the *seringuero* is unusually active. A *seringuero* usually lays out two or three *estradas* which are tapped in turn.

Tapping is begun in the early morning and finished well before noon, when the *seringuero* goes home to breakfast. Scien-

tific tests in the oriental plantations have shown the correctness of this procedure which takes into account the fact that the latex flow falls off toward noon. This is undoubtedly due to the increased loss of water from the leaves during the heat of the day which lowers the pressure which forces the latex out of the tubes in the bark, where it is produced.

The tapping is done by making gashes in the bark with a small axe, the *machadinho*. This gash cuts through the latex vessels of the bark and allows the latex to flow out. The cut is made diagonally so that the latex flows down to one end of the cut where a small tin cup is fixed by thrusting its sharp edge into the bark. The flow of latex continues for an hour or two usually, and is stopped by the plugging of the tubes in the bark, by the rubber which coagulates there. The number of cuts made varies with the size of the tree, small trees being given one cut, and large trees several cuts, but in all cases the number made these days is much smaller than was the case a few years ago. Pictures are extant of trees bearing 21 cuts on one side of the tree and presumably an equal number on the other. Such severe tapping is now unknown and we know now that it was very injurious to the tree and gave no higher yield than a smaller number.

By the time the *seringuero* has finished his breakfast the flow of latex has ceased and collection begins. The latex is emptied from the cups to a small tin milk pail which in turn is emptied when full into a cloth bag waterproofed with rubber. It is then carried home for coagulation which is obtained by smoking over a fire. The fire is built either in a pit covered with a dome of clay which has a small hole in the top, or is covered by a tin cone which concentrates the smoke. Sometimes the latex is smoked on a paddle like a canoe paddle, which is alternately dipped in the latex and held over the smoke which coagulates the rubber, changing the film of latex to a thin film of rubber. A cake of rubber is thus built up on the paddle in thin layers. When all the latex has been coagulated the cake is slipped off the paddle and set aside to dry. Usually a pole is used instead of a paddle and this is supported by ropes, or by horizontal poles laid on stakes set in the ground. The latex is then poured over the cake forming in the middle of the pole and the pole is swung or slid into the smoke to harden the rubber. Then this is brought back over the pan of latex and another film of latex poured over the cake, the excess dripping back into the pan.

In this way a large ball is built up on the pole which is increased from day to day until it reaches a weight of about 150 pounds. Then it is taken from the pole to dry and a new ball begun. These large balls are the form in which most of the Amazonian rubber reaches the market.

This method of preparation is slow and unpleasant for the *seringuero,* and various other methods have been suggested but most of these are not practical. The present method is simple and produces excellent rubber, and the writer considers it the best method available under the conditions. The methods used in preparing plantation rubber require careful control and an equipment not available to the *seringuero* so that it is questionable whether they can ever be adapted to the preparation of wild rubber. Unless properly carried out they yield a rubber greatly inferior to that made by the present method. Most of the improvements on the native method have been suggested by persons not fully acquainted with conditions and are of no worth whatsoever.

If the *seringuero* is working inland he has to carry his rubber on his back to the nearest stream navigable by his canoe, since there are few places where mules are available for transportation. Frequently the rubber has to be carried for days in the canoe before the trading post of the *patron* is reached and the crop turned in to discharge the debt against the *seringuero.* All too often, the debt is only partially lifted and the poor *seringuero* is given a miserable grubstake with which he must make his long return journey to begin again to attempt to harvest enough rubber to pay his debt and have something left to show for his labors. A great many never are able to pay their debts and live on in this slavery year after year until malaria or other tropical diseases end their miserable lives. The rubber is given in exchange for goods and the price which the *seringuero* secures in this way is always low, sometimes not more than 3 to 5 cents per pound. The price usually remains the same regardless of fluctuations in the market price of rubber and a rise in price only means more profit for the patron. It would be hard to find a more forlorn and downtrodden group of workers than these jungle dwellers. Many of the *patrons* grow wealthy and powerful even in this day of low prices, but since the boom days of the rubber country no *seringuero* has received a decent return for his labor.

The life of the *seringuero* is always a hard and a lonely one

due to the low return for his work, the poor food, the lack of medical care, and the bad living condition in general, but the dangers which he, or the traveller or explorer in these regions, encounter have been somewhat exaggerated. There are no dangerous mammals in the country—the jaguar, the largest, is powerful, but cowardly where man is concerned, and very rarely attacks a man. A number of poisonous snakes are native to the country but these are not frequently encountered in spite of all that has been written about their abundance. Discomforts there are in plenty, some of them due to animals such as the sand flies and mosquitoes, but as for dangerous animals one must certainly rank the malaria mosquito as the greatest menace.

There are several types of rubberbearing plants in the Amazon Valley. All that has been said thus far applies to the rubber tree par excellence, Hevea brasiliensis. This is the tree grown on all the eastern plantations and the only one which has proved thoroughly satisfactory as a plantation tree. The native home of this tree is the Amazon valley and the seeds which were the start of the eastern plantations were taken to Kew Garden from the lower Tapajos Valley, and from Kew to Ceylon and Singapore.

Beside Hevea brasiliensis there are a number of other species of Hevea which are native to the Amazon country. Some of these yield no rubber at all, others produce fair rubber but are not of much significance in the total output of rubber from Brazil and Bolivia. There is, however, a considerable amount of rubber secured from a tree of another genus, Castilloa Uleii. This rubber is known as *caucho* and is harvested by a method quite different from that by which the Hevea rubber is secured. *Caucho* trees do not respond well to continuous tapping because, though they give a very large yield at the first tapping, they will not give any latex at all on subsequent tappings until several months have elapsed. Also tapping usually causes great injury to the bark so that great patches of bark die and the whole tree may be killed. Therefore the common practice is to fell the trees and tap them by cutting rings around the tree at intervals of three or four feet. The cuts extend through the bark to the wood and open all the latex vessels so that the latex is drained out and collected in containers or allowed to collect in holes under the tree. Coagulation is brought about by the addition of juices from native vines or by allowing the

latex to stand until it ferments. The rubber is then washed in water and beaten out into flat sheets which are dried and bound up in bundles which are tied around with strips of rubber. One can always tell these bundles from the balls of Hevea rubber at a glance.

Since all the *caucho* trees are destroyed in tapping their number is being reduced very rapidly and the *caucheiroes* have to go long distances up the smaller streams to find trees to work. The time is not far distant when all the trees which are accessible will have been destroyed, and although many others exist in the interior the relatively low price of rubber will not justify the collection of rubber from them.

The *caucho* tree grows on the high land above the level of flood water. The Para rubber tree, Hevea brasiliensis, is found on low ground along the rivers and the trees first tapped for rubber grew in such a habitat. This gave rise to the idea that such a situation is the ideal one for the tree and that it will grow well only in swampy land. This notion is still held by many but is faulty. The finest trees are always found on well drained land well above the reach of floods. The trees along the rivers have shallow and malformed root systems and are not comparable to the fine upland trees, either in development or yield. In plantation practice it was soon found that the tree needed a friable well-drained soil.

Whether plantations in the Amazon valley will prove a success is yet to be determined since there are no planted areas great enough in size to be called real plantations, and the small plots which have been planted around houses in many places have not been properly planted or well tended. At present therefore one has no adequate data for a comparison with the oriental plantations. However there is no question that trees have grown to great size and have given wonderful yields in the Amazon jungles. But these trees have been long in growing, how long one cannot be certain; from studies on felled trees and borings in others the writer has estimated that the largest trees must be several hundred years old. Many of them must have been lusty trees when Columbus discovered America. It is not possible to compare the yields of such trees with those from plantation trees only 10 to 20 years of age.

The rate of growth has been shown by investigations of the author made on plantation trees in Sumatra to be closely correlated with yield. Hence it becomes necessary to know, not

only that the trees will grow in South America, but to know that they will grow as rapidly as in regions where the plantations have been a success. Such studies as could be made on planted trees in Brazil and Bolivia indicate that the growth of trees properly planted there will grow well and compare favorably with those of Sumatra or Malaya. In general it appears that plantation trees grow about ten times as fast as jungle trees, and if this is true we may expect that the South American plantations will make a satisfactory growth.

The finest wild rubber from South America comes from the Acre Territory of Brazil and Bolivia. Soil, climate, and other similar factors there are almost ideal for the growth of the tree, and this area is indicated as best for possible plantations. However this country is relatively inaccessible as it requires about a month's journey from Para on the river boats to reach it. This is a serious difficulty and for the present, possible planters are likely to look with more favor on a less distant site. Most of the land in the lower Amazon valley is less suitable for rubber planting because it has an inferior soil, and the dry season is more protracted, a factor which may greatly reduce the rate of growth of the trees. Some of the valleys of the lower tributaries are, however, little inferior to the Acre district and good plantation sites may be found not too far from the Atlantic coast.

One of the possible dangers to plantations is the South American leaf disease which has proved disastrous to the rubber plantations in British and Dutch Guiana. This disease is common in Brazil, where it seems to cause little damage to the wild trees, but it is not certain that the planting of large areas of rubber might not cause a serious outbreak. The conditions which favored the epidemic in the Guianas were peculiar and it may be that they will not be duplicated in Brazil. It may be, too, that further study will give us a method of control which will keep the disease in check. Only plantation trials will determine the extent of the danger, which does not at present seem great enough to prevent such trials being made.

The lack of a large population in the Amazon valley makes it appear likely that an adequate labor supply will be hard to secure. It is true that there is not labor enough there to care for any great area of land in plantations, but there is little likelihood that there will be a sudden development of a large number of plantations. A very considerable number of *serin-*

gueroes could be recruited from the rivers, if they had the promise of regular work, fair wages, and good living conditions. Wages are higher in Brazil than in the Orient, but good Brazilian workers will probably prove superior to most Orientals and as methods of rubber culture improve somewhat less labor is needed than formerly. For instance the number of tappings needed to produce a given amount of rubber is smaller now than it used to be. It is possible, also to use machines for some of the work done by hand in the East although tapping will probably always be a hand process.

The item of transportation is all in the favor of South America as compared with the Middle East because the distance to New York is so much less. This will help to offset the difference in the labor cost already mentioned. The shipment of supplies from America to the plantations will have the same comparative economy.

In one respect plantations in Brazil or Bolivia will have a unique opportunity in that they will be able to secure their planting stock in the region to which Hevea brasiliensis is native. There are some strains of the species which have never been introduced into the plantations and these may prove of special value. The black rubber tree is such a strain and there is little doubt that it is different from the eastern plantation tree in several respects. It has a very soft bark which is very dark in color, which gives it the name of black rubber. The latex flows from the bark very readily and tremendous yields are recorded from some of the trees. It is possible to secure planting stock of this kind for the plantations and it may be that this strain will prove much better than anything now in cultivation. Some scientific work is needed in the selection of the planting stock, but the chances of unusual success justify the effort. Since the export of rubber seeds from Brazil is forbidden this material cannot be secured by the Eastern plantations at the present time, so that the Amazonian plantings have a decided advantage in this respect.

There is no question that there is a great quantity of wild rubber unharvested in the Amazon valley. A conservative estimate puts the number of untapped trees well in the millions, and if these were properly tapped a large amount of rubber could be obtained for a number of years. But the most of these trees are so far removed from the rivers which are the only means of access to the country, that it is very doubtful

whether this rubber will ever be secured. Only a great crisis such as the complete failure of the eastern plantations, or a war which cut us off for an extended period from eastern supplies, would make rubber valuable enough to warrant its collection from these trees. So long as no other use is made of the land it may be just as well to have the untapped reserve as a protection against a possible rubber famine. There is little hope that any easy means of access to the distant lands will be developed in the near future, though it is not beyond the bounds of possibility. But even this would not make collection of the rubber practical at current prices. In spite of the study devoted to the problem little help has been given the rubber cutter in securing greater yields from his trees so that he may find it worth while to continue his work.

The wide distances between the trees is a disadvantage which cannot be overcome. It has been suggested that the *seringuero* plant trees in the *estradas* so that ultimately he will have a large number of trees near each other and thus be able to tap them economically. In the first place the *seringuero* cannot afford to do this under present conditions because he would be spending time which would bring him no return. The owners of the land have not had sufficient interest to pay for having such work done on their holdings, and at present few of these men can afford to make an outlay of funds for such a purpose. Most of them are land poor as it is, and many who were rich when rubber was high are now willing to sell their lands for a song. If they had had foresight enough to begin the work years ago, they might now be able to operate their properties at a profit, but the Amazonian has always been interested in exploitation of forest resources, not in cultivation. Now when some of them at least, see what might have been done, it is too late. Most of them, even now, realize only vaguely what has happened to them, and have a hope that the wild rubber will again be the *black gold* it once was to them.

A second reason why the planting is *estradas* is likely to fail is that the trees grow very slowly when planted in the shade of the forest. It appears that treees in plantations grow about ten times as fast as the jungle trees, and this means that the trees in the *estradas* would be an unreasonable length of time in coming into bearing. To clear out the larger trees along the *estradas* would cost so much that there is a question whether it would be worth while, though if this method had been tried

twenty years ago it would probably have succeeded.

The use of eastern methods of tapping offers some advantage, if they are properly adapted to local conditions. Some years ago the use of the tapping knife was tried in a number of experiments, but the results were discouraging, at least to the Brazilians, who always say that all the trees tapped with the knife died at once. It is certainly true that the eastern knife would be a deadly weapon in the hands of the *seringuero* who has never been taught to respect any tree, least of all perhaps, a rubber tree. A new set of tappers would have to be trained who had never used the barbarous *machadinho*, and only virgin trees, never before tapped could be used. The axe, or *machadinho*, cuts through the bark to the wood and causes wounds, which in healing produce great warts, or knots, on the trunk of the tree, which make it impossible to use a tapping knife on tapped trees. With proper use of the tapping knife on virgin trees it may be that a sufficient increase in yield would be secured to make the practice profitable, but this has not yet been determined by trial.

Another type of knife, known as the Amazonas knife, has been developed which makes a much shallower cut than the eastern knife, and so can be used on old tapped trees. In some places this knife has superseded the *machadinho* and it is claimed that better yields are secured by its use. It appears that this practice might be extended.

It has already been pointed out that little hope of finding a better method of preparing the rubber than that now in use is to be entertained. However, it would be easy to improve on the care which the latex and the rubber receives generally. About twenty per cent of the rubber is either wasted outright or so damaged as to be salable only as offgrade rubber. With a little care, this loss could be reduced greatly, but it would be very hard to get the *seringuero* to give this extra care, because careful methods require control anywhere, and it is impossible to establish any sort of inspection on the *estradas* as they now exist.

On the whole, while one must admit that in some places, the use of improved methods and a little more energy than is usual, may make the collection of wild rubber profitable, in most places the practice is doomed.

The possibilities of success in planting rubber have been touched upon, but one can easily be over sanguine in this re-

spect. It must be remembered that the East is suffering at present from over-production and that the British are having a difficult time of it in holding the price of rubber at a profitable level by their restriction on the production of their estates. It appears likely that rubber will reach a lower price level before it goes much higher. Therefore it does not seem that rubber-planting offers a prospect of great profit anywhere, and one cannot guarantee its success in an untried region. On the other hand new estates have an advantage over many of the old ones which were planted improperly, or on poor soil. New methods are reducing the cost of production, and new strains such as exist in the Amazon valley may set a totally new standard of yields and bring success where others fail. All in all, it may be said that any concern seriously interested in planting rubber might well give careful consideration to the possibilities of the Amazon valley.

It is likely that only those concerns with large resources have a good chance of success in South America where conditions are very different from those in the Federated Malay States, in Sumatra, Java, or Borneo. In all these places there are experiment stations which are engaged in research on the problems of rubber planting, and which can give advice concerning the best methods for local practice. In South America such experiment stations have not yet been established, and the prospective planters must count on the necessity of employing their own technical men to direct the development of their plantations.

It will also be necessary for such concerns to develop their own organizations for recruiting labor, for providing hospitalization for laborers, etc. These conditions make it imperative that developments be undertaken on a rather large scale if they are to succeed.

If these conditions are met and plantations established which take full advantage of the present knowledge of rubber planting, as well as of the local peculiarities of the Amazon valley it may be predicted that rubber production there has a good chance of success. Certainly, if Americans are really interested in securing a supply of rubber near home and outside the sphere of British control there is no reason why the Amazon Valley should not be given a fair trial.

CURRICULUM STUDY IN NATURAL SCIENCE ELECTRICITY AND MAGNETISM.

By Elwood D. Heiss,
Milwaukee State Teacher's College,

Earland Ritchie,
Doane College, Crete, Nebr.

and

S. R. Powers,
Teachers College, New York City.

The major function of curriculum studies and in a broad sense possibly the sole function is to determine what pupils need to know. Before the findings can be made to function, the curriculum material must be organized as appropriate teaching units and arranged in the course of study in the proper grades.

Perhaps there is no better basis for prediction of needs for science than is obtained from analysis of the interests of children and the interests of educated individuals. Acceptance of this thesis implies therefore the need for such an analysis. This paper reports several analyses which have been made to determine what people need to know about electricity. Each of these will be considered in turn.

A preliminary study gave a measure of the relative importance of the subject of electricity. This was obtained from a count of the titles of articles pertaining to science which were listed in The Readers Guide of 1922-24. There were 15,448 listings about some phase of natural science, 6350 pertained to physical science and of these 1699 were on radio, 553 on something else about electricity, and 67 were on magnetism.[1] More than 36 per cent of the listings under physical science pertained to something about electricity and magnetism.

It is likely that no learning about electricity is so important to a child as that which is needed to answer his questions. Children's interests have been studied through the questions which they ask. One report[2] gives an analysis of 3500 children's questions. The importance of electricity and magnetism in these is indicated by the frequency of mention of the following

[1]It does not follow that there were this many articles for some are listed by both author and title and titles are frequently listed under more than one letter.

[2]C. A. Pollock. Children's Interests as a Basis of What to Teach in General Science. Educational Research Bulletin, Bureau of Educational Research, Ohio State University, 3:3-6.

topics: electricity, 349; lightning, 157; radio, 243; telephone, 25; compass, 6. Nearly 23 per cent of all the questions pertained to these five points. Another report gives an analysis of 3330 questions from 687 children[3]. In the outline of Magnetism and Electricity, which is given as Table I, we have listed under pupil interests the frequency of mention by the children of the various topics. There were, for example, in all the 6830 questions, 18 pertaining to magnetism.

An extended examination of the needs of the consumer[4] shows, among other things, the consumers' needs for knowledge of electricity. Under the heading, Harap's Study, we have checked those items listed by Harap as essential or desirable. For example, there are no checks for magnetism for nothing pertaining to this is listed by Harap. However, the item "House Wiring" is checked, for this author lists several things about house wiring which he has shown that the consumer needs to know.

It is likely that no activity is so commonly participated in by educated individuals as that of reading newspapers and magazines. It has been assumed, therefore, that an analysis of articles in newspapers and magazines relating to electricity will reveal some significant curriculum content. Curtis has reported an alphabetical list of the scientific terms found in 630 newspaper articles and has listed the number of articles in which each term is used.[5] In Table I under the heading "newspapers" is given the number of articles in which terms relating to each of our large sub-divisions occur. For example, magnetism found mention in 13 articles.

We have supplemented the reports on electricity in reading material by the results from a study of 122 magazine articles totaling somewhat more than 100,000 words. The magazines together with the number of articles from each are as follows:

	Copies	Articles
Popular Science Monthly	3	70
Outlook	12	12
St. Nicholas	12	14
Science News Letter	20	12
Review of Reviews	12	10
Atlantic Monthly	12	1
Scribners	12	1
World's Work	10	1
Ladies Home Journal	4	1

[3]F. D. Curtis. Some Values Derived From Extensive Reading of General Science. Teachers College, Contributions to Education, No. 163.
[4]Harap, Education of the Consumer.
[5]Curtis, op. cit.

In Table I, we have given under the heading Magazine Articles, the number of articles about subjects related to our main sub-division. For example, 3 of the 122 articles were on magnetism.

Finally we report an analysis of text books and courses of study. These show what successful text book writers and successful teachers think should constitute the course and are in a rather definite sense an expression of expert opinion. The following texts and courses were included in the analysis.

TABLE 1.

The Importance of Magnetism and Electricity as Revealed by Analyses

	Harap's Study	Courses of study (10)	Texts (5)	Pupil's Interests	Magazine Articles	Newspapers
A. Magnetism	......	7	5	18	3	13
B. Static electricity	......	4	3	225	4	14
C. Current electricity and its uses	......	......	......	......	......	......
1. Electric cells (chemical)	......	10	5	7	......	......
2. Common conductors and Insulators	......	4	2	12	9	......
3. House wiring and lighting	x	10	5	13	21	......
4. Household electrical appliances	x	10	3	10	6	9
5. Electromagnetism	......	10	5	36	15	......
6. Dynamos and motors	......	8	5	26	7	14
7. Electro-chemistry	......	4	0	7	2	14
8. Measurements and instruments	x	6	3	8	......	9
9. Construction and use of transformers	......	1	3	......	18	......
10. A. C. & D. C. currents	......	4	4	1	11	......
11 Rectifier	......	1	......	......	3	......
12. Electron theory of electricity	......	4	3	8	3	......
13. Explanation of electrical terms	......	......	......	......	3	......
a. Electromotive force	......	1	1	......	......	......
b. Potential	......	1	1	......	......	......
c. Resistance	......	1	2	......	......	......
14. Radio	......	......	4	310	3	167

TEXTS

Bowden, General Science with Experimental and Project Studies.
Caldwell and Eikenberry, Elements of General Science. New Edition.
Hunter and Whitman, Science of Home and Community.

Van Buskirk and Smith, Science of Everyday Life. Revised and enlarged edition.
Webb and Didcoct, Early Steps in Science.

COURSES OF STUDY

Columbus, Ohio	Newton, Mass.
Los Angeles, Calif.	Harrisburg, Va.
Richmond, Va.	Trenton, N. J.
New York City	Kansas (State)
Denver, Colorado	Minnesota (State)

Under the proper headings we show the number of texts and courses of study which make mention of each of the units of Table I. For example, the topic, Natural and Artificial Magnets, is mentioned in seven courses of study and three texts.

In Table II, we give in detail the terminology pertaining to electricity and magnetism which was used in 122 magazine articles. The figure following each term is its total frequency of use in these articles. In Table III we have attempted to give some further notion of what these articles are about by listing what we have called major ideas which are developed in them. The figures following the statement is the number of articles in which some development of the idea was given. Curtis[6] selected his newspaper articles from the whole field of science but there were among them a good proportion of articles on electricity. We have starred the terms of our list which are not contained in the list prepared by Curtis.

TABLE II.

Electrical Terms Used in the Magazine Articles and their Frequency of Use.

radio	475	insulator	27
tube (radio)	171	sensitive	26
electrical	137	interfere	24
wire *	109	jack *	21
frequency	90	hydrometer	19
switch	82	wireless	17
electricity *	62	set (radio)	17
socket	57	lead-in	15
electric	45	neutrodyne	14
transformer	36	detector-tube	13
watt	32	microphone *	13
M. F. D.*	31	conductor *	12
grid-leak *	29	vario coupler *	10
crystal	29	receiver	177
regenerative	28	current	137
insulated *	27	electron	122
positive (electricity) *	25	transmitter	92
relay *	22	circuit	85
cell (electric) *	20	antenna	70
transmission	15	bulb *	61
short-circuit	15	speaker (loud)	52
hydro-electric	14	lightning	48

[6]Curtis, op. cit.

fuse	13
electrode	12
distortion *	10
battery	192
broadcast	165
voltage	126
wave (radio)	102
aerial	85
coil	76
amplify	61
solder *	56
filament	48
resistance	44
binding-post *	39
audio *	37
plate	35
loop	32
plug *	31
selectivity	29
grid	28
variable condenser	44
motor	36
kilowatt	37
ground	33
charger (battery)*	31
telephone	30
tune	29
negative (electricity)*	28
radio-compass*	26
grid-condenser	22
generator	20
elements	18
photo-electric *	17
static	16
instrument *	15
alternating current	14
rectify *	13
headphone *	13
capacity	11
light (electric)	10

The following are words with a frequency less than 10. The number to the right indicates its frequency.

potential *	9
oscillate	9
electromagnet	8
super-station	8
armature *	8
ignition *	8
lightning-rod	8
compass	8
electrified	8
ampere *	8
magnetic field	7
primary	7
direct current *	7
telegraphy	7
brushes *	7
radiophone	6
electro-magnetic	6
magnetism	6
terminals	6
milliampere *	6
tickler	6
fading *	6
ether waves *	6
cathode-ray *	6
aurora borealis *	6
photocurrent *	1
heterodyne *	5
audion	5
shaft *	5
vacuum cleaner	5
electronic *	5
transmission line	5
electric power	4
magnets	4
cycle *	4
variometer	4
megohm	4
wave-length	4
transmitted	4
northern light *	4
radiating *	3
short-wave beam *	3
installation *	3
bolt *	3
high tension *	3
synchronize	3
electrician *	4
electrostatic *	3
kilowatt-hour *	3
lines of force *	2
bus-wire *	2
push-button *	2
log * (radio)	2
electrical field *	1
inductance	2
eliminator *	2
arc *	2
condenser	2
bell *	2
headset	2
field-strength *	2
radio-activity *	2
radiogram *	2
dielectric	2
telegraph	2
lightning arrester *	2
distributor *	2
Leyden Jar	2
pig-tail *	1
electrolyte	1
electroplate *	1
voltmeter *	1
galvanometer *	1
commutator *	1
electro-dynamic *	1
proton *	1
magnetized	1
etheric wave transmission	1
electrometer *	1
ohmic *	1
E. M. F.*	1

TABLE III.

Major Ideas Developed in the Magazine Reading.

	Frequency
Description and definition of lightning	11
Parts of a radio set	8
Nature of radio waves	8
Meaning of radio terms	6
Positive and negative connection	5
Symbols of radio parts	5
Electrical connections and circuits	5
Electron theory of matter	4
Complete hook-up of receivers	3
Structure of batteries	3
Kinds of radio sets	3
Tuning of radio sets	2
Heating effects of electricity	2
Care of radio battery	2
Development of radio as an industry	2
Use of switches	2
D. C. and A. C. currents	2
Sending pictures by radio	2
Structure of a telephone receiver and transmitter	2
Wiring of houses	2
Explanation of fading	2
Production of static electricity by friction	2
Definition of positive and negative electricity	2
Electricity produced by waterfalls	1
Electricity produced by tides	1
Electric power possibilities of Niagara Falls	1
Structure of a radio tube	1
Parts and principles of a motor	1
Detecting and remedying radio defects	1
Principle of generator	1
Uses of switch-board	1
Process of electro-plating	1
Insulation of wires	1
Charging batteries at home	1
Operation of loop antenna	1
Parts of a crystal set "Talking pictures"	1
Frequency	1
Electro-magnet and how made	1
How to solder joints	1
How to hook up electrical fixtures	1
Principle of loud speaker	1
High power transmission lines	1
Description of Leyden jar	1
Principle of induction	1
How to figure cost of current	1
Communicating pictures by telephone	1
Transmutation of elements by use of electricity	1
Possibilities of predicting weather by use of radio	1
Electrical device for measuring altitude	1
Use of cathode rays to kill disease germs	1
Experiments in short wave transmission	1
Use of electricity in combating insects	1
The radio compass as a guide to navigators	1
Effect of eclipse and sunlight on radio reception	1
Use of radio by churches and schools	1
Range of prices of radio sets	1
Problem of regulating radio broadcasting	1
Growing interest of women in radio	1
Educational opportunities by radio	1

Use of radio by police stations in large cities	1
Use of radio equipped motor cars	1
Use of water power to relieve coal scarcity	1
Description of Millikan's experiments on the electron and other waves	1
Comparison of lightning with earthquakes	1

The following skeletal outline contains the essential ideas about which may be arranged the material shown in this study to be most significant for training for the performance of those activities involving electricity which are most likely to become the interests or responsibilities of ordinary educated individuals. It contains material which may be adapted by proper development to almost any grade level.

The Study of Electricity.

I. How electricity is produced:
  (a) Chemical action
    (1) Simple voltaic cell
    (2) Dry Cell
    (3) Storage batteries (Lead storage)
    (4) How to connect cells. Series and parallel
    (5) Electron theory of electricity
  (b) Mechanical action
    (1) Nature of magnetic field and polarity
    (2) Electromagnet
    (3) The dynamo
    (4) Source of mechanical energy. Steam and water power.
    (5) Difference between direct and alternating current
II. Transportation of electric current to consumer:
  (a) Transformer (step-up and step-down)
  (b) High tension transmission lines
  (c) How the consumer's current is measured
    (1) The kilowatt meter
    (2) How to read the meter
    (3) Where the meter is located
    (4) How to calculate the cost of current
  (d) Explanation of the fuse
  (e) The various types of fuses
  (f) How to replace fuses
III. House wiring:
  (a) Sockets plugs and switches
  (b) General Principles underlying wiring in buildings
    (1) Wire placement
    (2) Insulation and dangers of faulty insulation
    (3) Use of extension wires
    (4) Use of outlets in walls and floors
    (5) Varieties of chief electric fixtures
IV. House Lighting:
  (a) Demonstration of heating effect of electricity
  (b) The various types of lamps
    (1) Carbon filament
    (2) Tungsten filament
    (3) Gas filled lamp
  (c) Efficiency of various types of lamps.
  (d) Units of measurement and measuring instruments.
    (1) Volt
    (2) Ampere
    (3) Watt
    (4) Kilowatt

(5) Kilowatt-Hour
(6) Watt-Hour
(7) The voltmeter and ammeter
(e) Lightning standards

V. Household electrical appliances:
(a) Heating devices (construction and cost of operation)
(1) Electric toaster
(2) Electric iron
(3) Electric heater
(4) Electric range
(5) Study of the relative costs of electricty and fuels used in the community.
(b) Electrical power driven devices (study of the various types and relative costs of operation)
(1) Construction and principle of operation of simple motors.
(2) Electric sweeper
(3) Electric washer
(4) Electric fan
(5) Electric sewing machine
(6) Electric refrigerator

VI. Uses of motors in the community:
(a) Trolley car
(b) Electric locomotive
(c) Electric automobile

VII. Electricity applied in communication
(a) The electric bell and buzzer
(b) The telegraph system
(c) The telephone
(d) The radio
(1) General principles underlying production and nature of electromagnetic waves.
(2) Construction and operation of the audion tube
(3) The various types of tubes
(4) Recognition of parts and their function in a radio set—condenser, induction coil, antenna, grid leak, telephone, audion.
(5) The batteries and their function
(6) Loud speakers
(7) Radio symbols and terms
(e) Static electricity
(1) How static is produced
(2) Kinds of static charges
(3) Laws of attraction and repulsion
(4) Explanation of induction
(5) Explanation of lightning
(6) Interference of static in radio

TEACHERS EVERYWHERE SEEK PROFESSIONAL IMPROVEMENT.

Of 845,000 teachers, principals, supervisors, and administrative officers in public elementary and secondary schools of the United States in 1926-27, 377,462 were enrolled in summer schools during the past summer, according to figures recently compiled by the National Education Association. Of these, 247, 227, or 29.2 per cent of the total number of school men and women of the country, were enrolled in teacher training or education courses. The largest proportion enrolled from any one State was 62.5 per cent from Colorado; Alabama came next, with an enrollment of 56.2 per cent; Oklahoma stood third, with 45.4 per cent; and Tennessee fourth, with 42.5 per cent of the teachers of the State enrolled in c ourses for professional improvement.

UNDER WHAT CONDITIONS CAN A NUMBER BE EQUAL TO ITS LOGARITHM?

By Smith D. Turner,
Assistant Dept. of Chem. Eng., Mass. Inst. Technology, Cambridge, Mass.

[Note: The following paper was sent to the Problem Editor. It is a solution to Problem 967. Since the solution is lengthy and at the same time very interesting the Problem Editor sent it to the Mathematical Editor with the suggestion that it be published as a general paper.—Math. Ed.]

"Under what conditions can a number be equal to its logarithm?" (1)

The following is what we had in mind when proposing this problem:

if $\log_y x = x$ (2)

from the fundamental definition of a logarithm $y^{\log_y x} = x$ (3)

we have $y = x^{\frac{1}{x}}$ which is the necessary relation between (4) log and base if a number is to equal its log. Hence the possibility of $\log_y x = x$ depends upon the existence of the quantity $x^{\frac{1}{x}}$, and to a given base y_1, there are r numbers equal to their log when $x^{\frac{1}{x}} = y$ has r roots. The following discussion is confined to real values of both x and y. (5)

Let $x = \frac{\pm m}{n}$, where m and n are positive integers, prime to each other. Then (considering only the real roots), since (6)

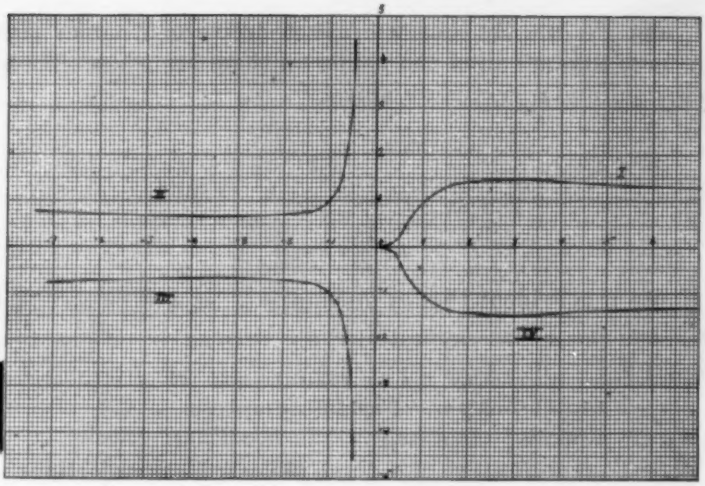
- *a*) An odd root of a (+) quantity is (+)
- *b*) An odd root of a (−) quantity is (−)
- *c*) An even root of a (+) quantity is (+) or (−)
- *d*) An even root of a (−) quantity is complex (7)
- *e*) An even power of a (±) quantity is (+)
- *f*) An odd power of a (+) quantity is (+)
- *g*) An odd power of a (−) quantity is (−)

We have, when x is (+) $y = x^{\frac{1}{x}} = \left(\frac{m}{n}\right)^{\frac{n}{m}}$ and so (8)

m	n	y	
even	odd	(+)and (−)	
odd	odd	(+)only	
odd	even	(+)only	(9)

and when x is (−) $y = \left(-\frac{n}{m}\right)^{\frac{n}{m}}$ and so

m	n	y	
even	odd	complex	
odd	odd	(−) only	(11)
odd	even	(+) only	



Plotting $y=x^{\frac{1}{x}}$ we obtain the curves shown in the figure. In the light of (9) and (11), however, we see that:

a) In branch I the line is a true curve (the function is continuous).

b) In branches II, III, and IV the function is discontinuous, and the "line" consists of an infinite number of points within a finite length. (The function is "dense but not continuous.") This is because of the possibility of approximating any given value of x to any desired degree of accuracy by $\frac{m}{n}$

The "line" representing branch II may be considered as a continuous curve, containing, within any finite length, two infinite sets of "holes," the first set corresponding, by (11) to those values $-\frac{m \text{ even}}{n \text{ odd}}$ which cause y to be complex, and the second set to those values $-\frac{m \text{ odd}}{n \text{ odd}}$ which place the point on branch III. There are two similar sets of "holes" in a continuous curve representing branch III. Considering branch IV in the same way, there are two infinite sets of "holes" corresponding to $+\frac{m \text{ odd}}{n \text{ odd}}$ and $+\frac{m \text{ odd}}{n \text{ even}}$ which place the value of y on branch I.

Since branch I is continuous, we may investigate its properties by methods of the Calculus. We find

a) y_{I} (max) $=e^{\frac{1}{e}}=1.445\ldots$ where $x=e$ (12)

b) Points of inflection at $x=4.44\ldots$ and $x=.60\ldots$ (roots of the equation $\log_e x=1-x\pm\sqrt{x^2+x}$). (13)

c) The line $y=+1$ is an asymptote. (14)

Being discontinuous, we cannot so investigate branches II,

III, and IV directly, but we may conceive continuous curves that pass through all of the points on these branches. Then on these continuous curves we may say

$$\begin{aligned} y_{\text{II}} &= \frac{1}{y_{\text{I}}} \\ \left|y_{\text{III}}\right| &= \left|y_{\text{II}}\right| \\ \left|y_{\text{IV}}\right| &= \left|y_{\text{I}}\right| \end{aligned} \qquad (15)$$

Hence it is evident that *a*) $y_{\text{II}}(\text{min}) = e^{\frac{1}{e}}$ at $x = -e$ and II has $x = 0$ and $y = +1$ as asymptotes; *b*) $y_{\text{III}}(\text{max}) = -e^{-\frac{1}{e}}$ at $x = -e$ and III has $x = 0$ and $y = -1$ as asymptotes; *c*) $y_{\text{IV}}(\text{min}) = -e^{\frac{1}{e}}$ at $x = +e$ and IV has $y = -1$ as an asymptote. (16)

We are now ready to answer (1) in two different ways.

FIRST, ignoring for the time philosophical objections, we may say that *any* value of x may be expressed by the form $\pm\frac{m}{n}$. (Obviously this can be done to any desired degree of accuracy.) Hence we see from the plots (17)

Base of logs (y)	Number of quantities equal to their log. (No. of values x)	Nature of x.
$y > e^{\frac{1}{e}}$	1	negative
$e^{-\frac{1}{e}} < y < e^{\frac{1}{e}}$	3	when $1 < y < e^{\frac{1}{e}}$ 2(+) and 1(−)
		when $e^{-\frac{1}{e}} < y < 1$ 1(+)and 2(−)
$o < y < e^{-\frac{1}{e}}$	1	positive

and similarly for negative values of y.

SECOND, realizing that a value of y might correspond to a "hole" in one of the branches, we have as an answer to (1) the values given by (17) with the further limitations that x is non-existent unless expressable in the proper form of $\pm\frac{m}{n}$.

Objection may be made to the taking of the logs of negative numbers as real, for generally they are complex, but periodically the imaginary part of a complex quantity vanishes, and it is the resulting discontinuous real points that we have obtained. As a concrete example $2^{\frac{1}{2}} = +1.414......, -1.414$

Base of logs (y)	Number of Values of x	Nature of x
$y>e^{\frac{1}{e}}$	1	X_1 of form $-\dfrac{\text{m odd}}{\text{n even}}$
$1<y<e^{\frac{1}{e}}$	3	X_1, X_2 positive
		X_3 of form $-\dfrac{m\text{ odd}}{n\text{ even}}$
$e^{-\frac{1}{e}}<y<1$	3	X_1 positive
		X_2, X_3 of form $-\dfrac{m\text{ odd}}{n\text{ even}}$
$o<y<e^{-\frac{1}{e}}$	1	X_1 positive
$o>y>-e^{\frac{1}{e}}$	1	X_1 of form $+\dfrac{m\text{ even}}{n\text{ odd}}$
$-e^{-\frac{1}{e}}>y>-1$	3	X_1 of form $+\dfrac{m\text{ even}}{n\text{ odd}}$
		X_2, X_3 of form $-\dfrac{m\text{ odd}}{n\text{ odd}}$
$-1>y>-e^{\frac{1}{e}}$	3	X_1, X_2 of form $+\dfrac{m\text{ even}}{n\text{ odd}}$
		X_3 of form $-\dfrac{m\text{ odd}}{n\text{ odd}}-$
$-e^{\frac{1}{e}}>y$	1	X_1 of form $-\dfrac{m\text{ odd}}{n\text{ odd}}$

Therefore by (3) we have $\log_2 +1.414.... = \frac{+1}{2}$ and $\log_2 -1.414.... = +\frac{1}{2}$

If it is desired to limit the discussion to positive numbers, the following simple answer (without limitations) to (1) results:

If the base of the system of logs is greater than $e^{\frac{1}{e}}$ there is no number equal to its log. If the base is between 1 and $e^{\frac{1}{e}}$ there are two numbers equal to their logs. If the base of the logs is between 0 and 1, there exists one number equal to its log.

THE NEED FOR STANDARDS IN COURSES IN THE TEACHING OF GENERAL SCIENCE.[1]

By J. O. Frank,

State Teachers College, Oshkosh, Wis.

There were offered during the year 1926-27, in the various colleges, normal schools, and universities of the United States, at least seventy different courses dealing with the Teaching of General Science. It is difficult to gather authentic information regarding the nature of some of these courses because some teachers do not care to give out information regarding the content of their courses. Fortunately, others gladly give such information. From outlines and other specific information furnished by teachers, from catalog descriptions, from direct observation, and from information furnished by teachers who have been students in the various courses, the nature of more than half of the courses offered, has been learned.[2]

Lack of Standardization of Courses.

The outstanding fact about courses in the teaching of General Science, in the various teacher training institutions of the United States, is that these courses vary widely in about every way possible. Courses in the teaching of other high school sciences also tend to show individuality in many ways, but none exhibit the extreme variation shown by courses in the Teaching of General Science.

Variations Shown in Courses Devoted Wholly or Chiefly to the Teaching of General Science.

1. Time and Credit Given.
   (a) In regular semesters, 9, 12, or 18 weeks, two, three or five class periods per week, and carrying 2, 3, 4, or 5 credits.
   (b) In summer schools 4, 5, 6, 9, or 10 weeks, usually five class periods per week and carrying 2 or 3 credits.
2. Nature of Courses (Types of Courses.)
   (a) Review of the subject matter of General Science.
   (b) Review of subject matter, with some attention to methods.
   (c) (No subject matter.) Course devoted to aims, principles of selection and organization of subject matter, texts, tests, methods, etc.
   (d) The investigation of problems involved in the teaching of General Science, with methods of investigation stressed as much as the problems. (This type of course is given much less often than the other three, which are about equal in frequency.)

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[1]Read before the General Science Section of the Central Association of Science and Mathematics Teachers, at Detroit, Nov. 25, 1927.

[2]It should be said at this point that this study has been qualitative and not quantitative in nature. It is doubtful whether a quantitative study of science courses would disclose information of any great value. Nothing would be proved as to *what should be done* in science courses, by any facts as to *what is done*. For purposes of this paper, at least, no quantitative study is needed.

3. Names of Courses.
   (a) "General Science for Teachers."
   (b) "The Teaching of General Science."
   (c) "Methods of Teaching General Science."
   (d) "The Teaching of Elementary Science."
   (e) "Principles of Science Teaching with Special Reference to General Science."
   (f) "Problems Involved in the Teaching of General Science."
4. Levels of Courses.
   (a) Undergraduate.
   (b) Undergraduate and Graduate.
   (c) Graduate.
5. Departments Giving Courses.
   (a) Education.
   (b) Biology.
   (c) Chemistry.
   (d) Physics.
   (e) Agriculture.
6. Flexibility of Course.
   (a) Entire course is set, "*take it or leave it*" type. The instructor has something he wants to give and gives it.
   (b) Some flexibility to meet student needs.
7. Required Student Activities.
   (a) Study of General Science texts.
   (b) Laboratory work in General Science.
   (c) Study of books on Science Teaching.
   (d) Reading periodicals and other literature on Science Teaching.
   (e) Special reports.
   (f) Term papers.
   (g) Listening to lectures.
   (h) Keeping notebooks.
   Each course requires some combination of these activities.
8. Qualifications of Teachers.
   (a) Teachers with little or no experience in actual class-room, teaching of science, persons strong in theories of education, but lacking in experience, giving courses largely theoretical and of little practical value.
   (b) Teachers with many years of experience in teaching various high school sciences, including General Science, with little knowledge of the various educational theories and sometimes with much contempt for same.
   (c) Teachers with adequate training in both Education and Science, teachers who know science thoroughly and who know education just as thoroughly. Teachers with broad experience in Science Teaching.

THE BAD EFFECTS WHICH RESULT FROM THE LACK OF STANDARDIZATION OF COURSES IN THE TEACHING OF GENERAL SCIENCE.

1. Teachers have difficulty in transferring credits for a course from one school to another, unless an outline of the course is furnished. Teachers may take two or even three entirely different courses under same name (The Teaching of General Science) or may have the same course under two different names.
2. A teacher may take a subject matter course and not go further because there is doubt about credit, or because of probability of duplication of work already done.
3. Teachers are frequently unable to tell from the name and a brief description of a course whether or not it offers further material worth while. A teacher may need subject matter and on entering a course get educational theory, or need information and instruction as to best educational theories and practices and get subject matter.
4. Having no standards to go by, teachers of these courses give what-

ever they happen to know best. Their students have been known to sit through weeks of lectures on subjects of no interest to them, so that later on in the course, they might get a few things which were of real value.

5. Because no college credit is given, teachers frequently fail to take much needed courses in subject matter.

The present lack of standardization of courses in the Teaching of General Science, results in discouragement and loss to teachers and prospective teachers of General Science. It will be a great advantage to them when a definite sequence of courses of rather well defined content based on the actual needs of teachers, is established. Then one of these courses may be taken in one university and the next in another without duplication or loss.

Suggested Remedial Measures.

Much good would undoubtedly result if a definite sequence of courses of fairly definite content for teachers of General Science could be decided upon and recommended by a competent committee of science teachers. The report of such a committee would go far towards establishing standards in courses in the teaching of all the high school sciences, and would aid teachers in arranging a progressive program of study in preparation for the teaching of science. It would be difficult to persuade some schools that any subject matter course in General Science ought to carry college credit, but if all the facts were clearly shown, this would finally be accomplished.

It is suggested that three courses might form a sequence which could be made to cover all the fields now treated in the various undergraduate and graduate courses dealing with the teaching of General Science.

This sequence is offered as a basis of discussion and a point of departure in case a committee attempts to study needs and make recommendations.

A Proposed Sequence of Courses.

A. TEACHERS COURSE IN GENERAL SCIENCE. An undergraduate course dealing primarily with the broad general principles and the larger aspects of the subject matter of General Science. A course in professionalized subject matter, but with some attention to actual methods of instruction. A course on the college level. 2 credits.

B. THE TEACHING OF GENERAL SCIENCE. A course for graduates and undergraduates. Aims, selection and organization of subject matter, methods, texts, tests, etc. Prerequisite: Course A, as described above or one year each of Physics, Biology, Chemistry, and Geology, or the equivalent. 2 credits.

C. METHODS OF INVESTIGATION OF PROBLEMS INVOLVED IN THE TEACHING OF SCIENCE. A strictly graduate course, dealing with methods of investigation and intended to find and train persons who have ability to contribute to science education. 2 credits.

Objectives of the Courses Recommended Above.

A. Teachers' Course in General Science (A Subject Matter Course).

The very fact that one-third, if not one-half, of the courses for teachers of General Science are courses which deal to a large extent with the subject matter of General Science is strong evidence that there is a need for a subject matter course, and no argument is being made here that such a course is not needed. On the other hand, the subject matter offered in many courses is plainly of secondary school level and it is difficult to see how college credit can be given for it. Many schools absolutely refuse to give any credit for such a course.

It would seem that a subject matter course might be given on a college level. Many other secondary school subjects are treated again in college, the work being given on a higher plane, and no objections are heard.

There are other excellent reasons why a subject matter course ought to be available for teachers preparing to teach General Science.

1. We know that the average high school graduate still gets but a patch work of science. The rather isolated bodies of scientific knowledge obtained in one, two or three units of science cover no complete or unified field. Certain fields of science are taboo and have not been touched. Such units as have been treated do not dovetail; they do not develop a useful understanding of the broad general principles of science. There are great gaps or holes, connecting fields which have not been touched. There has been no summarizing course to weld these units into a connected whole. The student still thinks in terms of the units of science rather than in science as a whole, in terms of isolated experiences rather than broad general principles.

2. There is still a great body of traditions, superstitions, and half truths, which is the heritage of every child who enters the public schools or has social contacts with the American public. Old ladies' tales, belief in luck, weather signs, foretelling future events, charms, and magic cures for disease, and the like are quite common, and undoubtedly influence the events of everyday life.

3. Newspaper and magazine science with all its half truths and glaring inaccuracies (such as stories of men living in the age of the dinosaurs and accounts of the discoveries of famous scientists of whom no one has ever heard), is a potent factor in bringing to the young American student a mass of misinformation, which high school science seems unable to dispel.

It can safely be declared that the average high school graduate who is preparing to teach, is still a sceptic about many important generalizations of science. What he has learned in high school, the things commonly believed by his parents and associates, and what he reads—do not agree. For some reason, he knows he has been left in almost complete ignorance about certain things, —but he has learned enough to know that he needs to learn more.

To fill in gaps in high school science, to treat important fields

not treated in high school, to organize high school science as a whole, to clear away superstitions and beliefs in the pseudo science of newspapers and of tradition, and to dispel the scepticism of the average high school graduate—a unifying course in General Science on a college level is needed by every person who expects to be a teacher, and most especially by those who expect to teach science. Such a course is quite practicable and is already required in many schools, in curricula for the preparation of high school teachers.

Objectives of a Teachers' Course in General Science.

Primarily a subject matter course. Not the details of the various topics of General Science, but the important generalizations of the various fields—especially of those fields not usually treated in the high school. Some attention should be given to methods and other classroom problems.

1. To bring prospective teachers up to a definite standard of understanding of science as an organized body of knowledge.
2. To develop orientation, perspective and background founded on true science.
3. To clear away superstitions, traditional misbeliefs, and the pseudo science of the street.
4. To give actual information and instruction in important fields not covered by the high school sciences.
5. To give contacts with the best scientific books and periodical literature.
6. To further develop appreciation of the importance of scientific discoveries and of the works of the great scientists, and give confidence in science as a potent force in advancing human progress.
7. To give a preview and lay a foundation for the study of traditional sciences on a college level.
8. To develop new interests in science, especially in new fields of science.
9. To develop an understanding of the place of science in the future development of the resources and industries of the United States, and in national defense.
10. To give opportunity for questions in fields in which the student has so far dared not satisfy his curiosity.
11. To give a preview of the problems involved in teaching General Science, together with an introduction to the literature of science teaching.

Teachers' Course in General Science.

Some Suggested Units.

1. The Place of the Earth in the Solar System.
2. The Solar System and the Universe.
3. Origin and Evolution of the Earth.
4. The Origin of Life.
5. The Origin and Evolution of Man.
6. Early Steps in Human Progress.
7. The Evolution of Society.
8. History of the Theories of Evolution.
9. Present Status of the Theories of Evolution.
10. Heredity and Eugenics.
11. The Control of Disease.
12. Modern Means of Communication.
13. Modern Transportation.

14. Science in Warfare.
15. Science as a Means of Progress.

(Each topic is taught not only for the subject matter but also to demonstrate the methods best adopted to the teaching of General Science.)

B. The Teaching of General Science.

Little need be said in argument for a course dealing with the methods and materials of General Science teaching. The evidence of a need for such a course is complete. The need is undisputed. There is, however, still great difference of opinion as to what ought to go into such a course. The course suggested here is based on reports gathered from more than two hundred science teachers. With the exception of subject matter, it deals with materials mentioned most often by teachers as their most difficult problems.

It must be admitted that General Science is still poorly taught in the average school. Frequently the legitimate objectives of the course are not accomplished at all. It is true that great progress has been made in the past five years. We have better texts, good courses of study have been prepared, many teachers are coming to recognize the importance of General Science and to study the various aspects of general science teaching,—but the public, many administrative officials, and a large percentage of general science teachers still lack the spirit of the subject, they still are without the point of view and the philosophy of it they ought to have.

The subject has a place of strategic importance in our scheme of secondary education and especially of science education. Here new study habits are being formed, new methods of problem solving are being learned, new attitudes established, new impressions of new fieids being produced,—all this as in no other high school subject. In this scientific age these habits of study, these methods of problem solving, these impressions and attitudes are of exteme importance—we need our very best science teachers at this point.

A course for these teachers ought to deal with materials which will be of greatest immediate value in giving teachers the point of view of General Science, helping them to understand its place and importance in our scheme of education and bringing to them all possible aids to actual classroom instruction.

Objectives of a Course in the Teaching of General Science.

The value of a course in the teaching of general science must be measured in terms of the understandings, abilities, ideals, perspectives, attitudes, and the like it induces in the members of the course, and the desirable changes wrought in their teaching. The ultimate objectives

are, then, the production of these ideals, abilities, attitudes, understandings, and the like. An analysis of the ultimate objectives seems to indicate the validity of a number of intermediate objectives, as follows:—

1. To give the orientation, perspective, and background required for an intelligent study of the problems involved in the teaching of general science.
2. To define the more important problems of general science teaching.
3. To describe and study the more fruitful methods of educational investigation and evaluate the usefulness of each in solving the problems of general science teaching.
4. To show the limited value of opinion, and to develop an appreciation of the permanent value of the findings of properly conducted research.
5. To open up new interests in the field of general science teaching.
6. To acquaint the student with, and interest him in, the more important literature relating to science teaching, and in the men and institutions which have produced it.
7. To present, discuss, and evaluate the current methods and plans for teaching general science.
8. To present and evaluate the various materials and devices used in teaching or enriching the course in general science, such as:—books and other literature; tests; apparatus; illustrative materials of all kinds, including slides and films; new experiments.
9. To present directly and in some detail tried methods of teaching some of the more difficult phases of general science.
10. To give direct information as to best practices, costs, methods of selection and purchase of supplies, and other similar topics relating to laboratory instruction and laboratory maintenance.
11. To give direct instruction in the technique and methods of experimental demonstration as applied to the teaching of general science.
12. To give direct advice and assistance to students who wish aid in the solution of their own teaching problems.
13. To give advice and assistance to each student who needs it, in determining the work for which he is best fitted, his needs in the way of professional training, and how to find and hold the position for which he is fitted.

SUGGESTIVE OUTLINE OF COURSE B

The Teaching of General Science.

I. *History of Secondary Education in the United States.*
  A. The early Latin Grammar Schools, the Academies, early High Schools. The Nature of these schools; what they contributed to the modern high school.

II. *Science Teaching in the High School.*
  A. In the first high schools.
  B. Before the Civil War.
  C. After the Civil War.
  D. After 1872.
  E. In 1900.
    The nature of the subject matter used; education theories and practices of each period, remnants from these periods that are still with us, and how they influence present day teaching.

III. *The Status of the Sciences in Present Day High Schools.*
  A. The junior high school sciences.
  B. The senior high school sciences.
  C. Standardizing agencies, what they are and how they influence science teaching.

IV. *The Origin and Growth of General Science.*
  A. The early courses; their nature, texts used.
  B. Growth in number and changes in type of courses. Evolution of general science texts.

C. The present status of general science. Types of courses.
D. Present practices in general science teaching.
E. Criticisms of general science.
F. Definition of the problems involved in teaching general science.

V. *The Role of Scientific Investigation in Present Day Education.*
A. The scientific attitude.
B. The scientific method.
D. Methods of investigation.
1. Typical methods.
2. Evaluation of methods.
3. How to use them.

Not for the purpose of developing technique, but to give understanding and appreciation of methods of investigation, and confidence in their findings.

VI. *The Aims of Secondary Education and the Role of General Science in their Realization.*
A. The place and aims of science in the graded school, in the junior high school, and in the senior high school.
B. Grade placement of each of the sciences in a twelve year program.

VII. *The Subject Matter of General Science.*
A. Factors affecting the selection of subject matter.
B. Principles underlying the selection and arrangement of subject matter.
1. Consideration of the work of Hopkins, Bobbitt, Charters, Harap, and others.
C. Principles of organization of subject matter.
D. Examination of typical courses of study.

VIII. *General Science Texts.*
A. The evaluation of texts on basis of general worth.
B. Selecting texts to fit particular needs.

IX. *Methods of Teaching General Science.*
A. Evaluation of traditional methods.
B. New methods.
C. The laboratory method.
D. The class demonstration.
E. Combinations of methods into plans of instruction.
F. A study of methods, plans of instruction and units of subject matter used by various cities.

X. *Ways and Means of Enriching the General Science Course.*
A. Curricular materials.
B. Extra-curricular materials.

XI. *The Measurement of Results.*
A. Kinds of tests and how to use them.
B. A study of standardized tests. How they are made and used.

XII. *The General Science Laboratory.*
A. Planning and equipping a laboratory.
B. The selection and purchase of supplies and apparatus.

XIII. *The Professional Problems of the General Science Teacher.*
A. Job analysis of the work of the general science teacher.
B. Fundamentals in the curriculum for the training of general science teachers.
C. Getting and holding a position.
D. Keeping efficient.

C. Methods of Investigation of Problems Involved in the Teaching of Science.

This course would be intended for mature teachers who give promise of being able to make contributions to education. It would be for the purpose of giving an appreciation and an understanding of the methods of investigation, and to develop ability and technique in their use.

We have a right to expect teachers of General Science:

(1) To know well the subject matter of General Science.

(2) To know how to teach General Science, to be able to teach it well, to have the proper point of view and the proper attitude towards the subject and to be able to accomplish the objectives of the subject. Not only this but to keep up-to-date in both science and education.

(3) When able to do so, to make contributions, however small, to the progress of education.

If we accept this point of view, we can see that an extended program of specialized study is necessary and the need for a standardized sequence of progressive courses of the type suggested, becomes quite clear.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
California Institute of Technology, Pasadena.

Was Darwin right when he said that man, under the action of biological forces which can be observed and measured, has been raised from a place amongst anthropoid apes to that which he now occupies? The answer is yes! and in returning this verdict I speak but as foreman of the jury—a jury which has been empanelled from men who have devoted a lifetime to weighing the evidence.—*Sir Arthur Keith, anthropologist, in "Darwin's Theory of Man's Descent as it Stands To-day," the presidential address before the British Association for the Advancement of Science, given at Leeds on August 31, 1927, and reported in Science, September 2, 1927.*

Believing as I do that man in the distant future will be a far more perfect creature than he now is, it is an intolerable thought that he and all other sentient beings are doomed to complete annihilation after such long-continued slow progress. To those who fully admit the immortality of the human soul, the destruction of our world will not appear so dreadful.

As for a future life, every man must judge for himself between conflicting vague probabilities.—*Charles Darwin in "Life and Letters."*

Science confounds everything; it gives to the flowers an animal appetite, and takes away from even the plants their chastity. —*Joubert.*

Plato having defined man to be a two-legged animal without feathers, Diogenes plucked a cock and brought it into the Academy, and said, "This is Plato's man." On which account this addition was made to the definition, "With broad flat nails."—*Diogenes Laertius in "The Lives and Opinions of Eminent Philosophers."*

SOME FACTORS OF SUCCESS IN PHYSICS.

By Virgil C. Lohr,
University of Chicago.

Teachers of special subjects and administrators of schools in which special subjects are taught share the responsibility of personnel administration of pupils. The teacher who is blind to the requirements for successful work in his subject, or who has only vague ideas of the importance of certain qualifications which he insists upon the pupil having before entering the work of his course, or who is not clear in his mind as to the contribution that certain procedure makes to success, cannot be of the greatest service in the administration of the pupils in his own classes and is of rather doubtful assistance to the principal or personnel director in making student adjustments.

Teachers of physics are fairly well in agreement that there are certain skills and abilities which may be expected as possessions of their students, among which are: certain powers and skills in mathematics, the ability to interpret the printed page, certain general information in science which may have been gained in other science courses and above all a sufficient mental capacity to insure profit from the course. In some cases it has been the custom for teachers to set down definite prerequisites for the course. It is not unusual to find mathematics through geometry, and one year of general science as among these prerequisites for beginning physics. All teachers of physics assume that the pupil has mastery of the tool subjects, such as the ability to use acceptable English, and the ability to read.

It was the purpose of this investigation to determine the extent of certain skills and abilities of beginning students in physics classes at the time of their admission to the courses and to determine to what extent these abilities and skills may have been factors in success in the course. The study will attempt to discover if possible, other factors that may make a contribution to success.

The classes used for the purpose of the study were the regular classes in beginning physics in the University High School, and the sections in junior college physics of the same school, which were taking the first course in physics. Three sections of twenty students each comprised the first group. In the college group, four sections of approximately sixteen pupils each were used in most of the study. In the case of the reading study the data were obtained from but two of the college sections.

At the beginning of the school year, in the case of the high school group, and at the beginning of the quarter in the case of the college groups, a test in mathematics was given each of the classes. This test was devised by the science department and was arranged to include those mathematical principles to be encountered repeatedly in the study of physics. The tests were scored on a percentage basis. A response was considered right only when it was accurately solved—that is, both the method and the solution were considered in the scoring.

Early in the courses the Ruch-Popenoe General Science test was administered and the scoring was done as per the directions of the authors.

In the college classes the Thurstone Test No. 4 was used in the rating of mental abilities. The Intelligence Quotients of the high school students were obtained from the records of the high school office. The Otis test had been used for obtaining these indices.

In order that some score on the reading ability of the students might be had, it was felt that two types of ability should be tested, namely—the ability to read accurately and the ability to make correct inferences from the material read. It was felt that the material of the physics text book would offer better material for these tests than any of the so called standard reading tests. To this end we arranged two tests. The directions and a sample of the tests are here given:

Reading Test for Physics Students.

Note. This is a test of your reading ability. It aims to test the rate at which you read and your ability to understand the printed page.

When the signal to begin is given, you are to read the first assignment of paragraphs and then you are to write the answers to the questions that are asked about the material in the paragraph. You may re-read the assignment as many times as you choose. When you have done your best on the first assignment, take the next and so on until time is called. You will be given ample time to do well. *Do Not Hurry.*

Assignment I. Read Section 121, page 102, Millikan and Gale (coarse print).

Questions:

(a) What sort of substances in general are good absorbers?
(b) Why are the substances referred to in (a) good absorbers?
(c) How do we know that substances differ widely in absorbing ability?
(d) Why is charcoal a good deodorizer?
(e) Why does platinum sponge suspended above alcohol glow?
(f) What practical use is made of this principle?

This was followed by six assignments, picked at various places from the text book, with similar questions arranged.

Reading Test No. 2.

Note. This is a test of your reading ability. It aims to test your ability to draw proper inferences from what has been read.

When the signal to begin is given, you are to read the first assignment of paragraphs and then you are to write the answer to the questions asked about the material in the paragraph. You may read the assignment as many times as you choose. You will usually not find the answer to the question asked, but you will find certain information given in the paragraph from which you can infer the answer. When you have done your best on the first assignment, take the second and proceed similarly. Then take the third and so on until time is called. You will be given ample time to do well. *Do Not Hurry.*

Assignment I. Read Section 207 and Sec. 208, pp. 172-173. M. & G.

Questions:

(a) Will a vessel filled with air and standing over water become saturated with water vapor? Yes or No.

(b) Will a vessel in which there is a vacuum, standing over water, become saturated with water vapor? Yes or No.

(c) If the vessels, filled as in (a) and (b) above are of the same size and if the same conditions otherwise are found for both, which will have more water vapor in it at the end of a short period of time?

(d) Will the space in any part of the vessel in which there is air become saturated with water vapor before another part is saturated? Yes or No.

(e) Is the air over the ocean always saturated with water vapor?

(f) Will a wet rag dry in saturated air? Yes or No.

(g) What effect on evaporation has air molecules above the surface of the lake?

(h) Does it require more water vapor to saturate air in a given space when that air is hot or when it is cold?

(i) Atmosphere always contains water vapor. What has happened when water vapor condenses?

This was followed by four assignments picked from paragraphs of the text that gave good material along this line. Questions of similar nature were formulated on each assignment. The time allowed for each of the tests was thirty minutes. In a few cases the students were able to complete the test in that time.

The results of all the tests are to be found in tabular form in Tables 1 and 2. (See the following page.)

In the reading tests the fact is disclosed that the accuracy with which the high school and junior college students read is not materially different. The range for high school students was from 51 to 98, with a median of 80. The range for the college group was from 31 to 82 with a median of 79.3. In the matter of inference drawing ability, there was greater ability shown in the college group. The median for that group was 76.25 and for the high school group 64. The range for the former was 23 to 90 and for the latter 38 to 90. It should be remarked that the low score in both the tests in the college group was made by a student who has been dealing with English language less than four years. By omitting this case the college groups show superiority in both tests.

One would suppose that ability to make correct inferences from reading matter would depend upon the ability of the individual to read accurately, and that a high correlation would be found

in the results of the two types of test. The correlation factor found for the high school classes was .3523±.0724, that found for the college classes was .4153±.1034. It seems evident that factors other than the ability to read accurately must be vital in determining the power to make correct inferences from reading material.

TABLE 1.

Scores Made by High School Physics Students in Various Tests.

Test	Highest Score	Lowest Score	Median Score
Mathematics	71	11	32
I. Q. (Otis)	149	93	118
Reading Accuracy	98	51	80
Reading Inference	90	38	64

TABLE 2.

Scores Made by Junior College Physics Students in Various Tests.

Test	Highest Score	Lowest Score	Median Score
Mathematics	80	22	49
Thurstone	132	43	82.5
Ruch-Popenoe	64	17	45.5
Reading Accuracy	82	31	79.3
Reading Inference	90	23	76.25

In the above case and for all correlations mentioned in this study, the product-moment method was used in the determination of the factor (r). For the purpose of our investigation, the factor was determined in a number of cases and these correlations are to be found in tables 3 and 4 (next page). The teacher of high school physics was kind enough to arrange his pupils into quintiles and assign to each pupil a per cent mark as an indication of his judgment as to the success of the pupil, for the purpose of our study.

A study of tables three and four show that in the college group the accuracy of reading correlates with the Thurstone test fairly well. The factor is .6260±.0758. The correlation of the same test in reading and the R.-P. science test gives a factor of .5584±.0874. This test shows no significant correlation with either the mathematics test or the final mark.

With this college group, the test of inference ability and the

Thurstone test show a factor of .5542±.0872, and with the mathematical ability test a factor of .4185±.1014. No correlation of consequence is found between this test and Final mark, and none of any significance between this test and the R.-P. science test.

These facts seem to suggest that the matter of accuracy of reading and accuracy in deduction must be self corrective. It can hardly be conceived that correlation does not exist between these factors and the final mark. This hypothesis can be settled definitely by a similar test administered at the close of the course and making a comparison of the scores with the scores of the early test. This has not, as yet, been done.

TABLE 3.
Inter-Correlations of Certain Tests Given High School Physics Students.

Tests	Correlation Factor (r)
Accuracy of Reading vs. Inference Ability	.3523±.0724
Accuracy of Reading vs. Intelligence Quotient	.1051±.0862
Accuracy of Reading vs. Mathematics Score	.2635±.0812
Accuracy of Reading vs. Final Mark	.2642±.078
Inference Ability vs. Intelligence Quotient	.3880±.0745
Inference Ability vs. Mathematics Score	.3548±.074
Inference Ability vs. Final Mark	.3367±.0751
Intelligence Quotient vs. Final Mark	.5558±.0617
Mathematics Score vs. Intelligence Quotient	.3474±.077
Mathematics Score vs. Final Mark	.4404±.0675

TABLE 4.

Inter-Correlation of Certain Tests Given Junior College Physics Students.

Tests	Correlation Factor (r)
Accuracy of Reading vs. Inference Ability	.4153±.1034
Accuracy of Reading vs. Thurstone Index	.6260±.0758
Accuracy of Reading vs. Mathematics Score	.2171±.1295
Accuracy of Reading vs. Ruch-Popenoe Science	.5584±.0874
Accuracy of Reading vs. Final Mark	.1009±.133
Inference vs. Thurstone	.5542±.0872
Inference vs. Mathematics	.4185±.1014
Inference vs. Ruch-Popenoe	.3149±.1105
Inference vs. Final Mark	.0537±.134
Thurstone vs. Mathematics	.5462±.087
Thurstone vs. Ruch-Popenoe	.2650±.0939
Thurstone vs. Final Mark	.0782±.048
Mathematics vs. Ruch-Popenoe	.2161±.1172
Mathematics vs. Final Mark	.4374±.1014
Ruch-Popenoe vs. Final Mark	.2851±.1141

In the high school groups we find little correlation of significance in so far as the reading tests are concerned. The matter may be explained on the ground that the students tested are "test wise." They have learned that the results of such tests have no bearing upon their final semester standing and do not give them the attention that other students might give. In going over the test with his classes, Mr. Holley was able to get the reaction from many of his pupils that they had read the material over but once and had taken a chance on answering right, rather than re-read the material. By the directions the pupil was permitted to re-read the paragraphs as often as he

chose. All of the students who finished the tests within the time limit were of the high school groups.

The relation of intelligence scores to success in physics, as indicated by the final mark, is fairly high in the case of the high school groups. The factor is $.5558 \pm .0617$. The basis of measurement in these cases was the Otis Test.

In the college groups we have used the Thurstone Psychological Examination No. 4. The correlation factor between the Thurstone indices and the final mark show utter lack of harmony. One cannot conceive of intelligence playing no part in success in physics. The inference might follow that one or both of our measures is faulty. The final marks given the college groups are a composite objective mark based upon the quality of the written work that was required from time to time in the course, test and quiz scores, and the final examination. No reference was made to the weekly reports (to be discussed later) of the pupils in arriving at the final mark. It is probable that the estimate of the high school pupil's success was more subjective than was the case of the college group.

It will be noted that the correlation between Otis I. Q. and mathematics is .34, while that of Thurstone and mathematics is .41. Otis I. Q. and inference drawing ability show a factor of .38, while Thurstone and inference tests show .55 as a factor.

We have no relative measure in the two cases for Intelligence vs. R.-Popenoe science as the latter test was not given in the high school classes. In the case of the college classes the factor is very low. This science test is largely a test of science information and one might expect a low correlation between the two.

On the assumption that the Thurstone index is a reliable measure and that the final mark is a measure of the student's success in physics, the only valid explanation seems to be that the number of cases is so small that the extreme deviates vitiated the results. In at least three cases of extremely high intelligence index we find low final scores, and in as many cases do we find extremely high final scores associated with low intelligence indices. The individual cases noted are explained on the one hand as cases of indifference, and on the other as cases of unusual and constant effort.

The relation of skills and abilities in mathematics as shown by our test and the final marks show correlations of $.4404 \pm .0675$ for the high school classes and $.4374 \pm .1014$ for the college group. In both these groups the test was administered primarily

to discover any mathematical weakness that might exist in order that corrective treatment might be given. It has long been the policy of the department to accept as a fact that students come to physics with marked inability to handle the mathematics that the course requires, and that it is the duty of the physics teacher to accept responsibility for its correction. It has been found that this may be made largely a matter of self-correction.

A study made by Mr. Holley, of the high school department of physics, of the mathematical skills and abilities of his pupils after a year of work in physics classes is of interest in this connection. By giving similar tests in mathematics to the classes at the beginning of the course and again at the end he was able to show the per cent improvement, in the case of each individual, which had been made during the year's work in physics. In practically every case there was a marked increase in the score and the average increase in six classes studied was approximately thirty per cent. That is, the score made at the end of the course was about thirty per cent higher than the score made at the beginning of the course. The data on this study may be found in the school reports for 1925 and 1926.

For several quarters past we have required each student of Junior College physics to hand in a weekly report of the number of problems he has solved independently, the number of pages of reference material he has read on the subject and the number of hours he has spent on physics, exclusive of the class time. As was noted elsewhere in this paper, the totals of these reports were in all cases, except for a very few problem cases, entirely unknown to the instructor who gave the final marks. These reports were tabulated and totaled by the student assistant. It is evident therefore, that these reports could have in no way colored the final marks directly. The correlations between these items and the final scores for the quarter are found in Table 5 (see next page).

The thing that stands out in this table is the importance of mathematical self help, as effected through the solution of physics problems, and the contribution that extensive reading has to success in physics. The factor between time spent and final grade is about what one would expect since the rate at which students work and the time required by different individuals for mastery of ideas is so variable.

It is apparent that one of the big factors in success is *effort*

on the part of the individual. The students who had noticeably low scores on the Thurstone test were the ones who solved the largest number of problems and who received the high final marks. These students were the ones who had read the largest number of pages of reference material also. The student of highest Thurstone score had solved the least number of problems, but had read rather extensively. By studying the individual students, one by one, it becomes apparent that the attitude of the student toward the work is a determining factor. The student who is inclined to take it easy and who is not interested in putting all his effort into the work, or who puts just enough effort to "get by," succeeds in doing little. On the other hand, those students with low Thurstone scores, low preliminary mathematics scores and low reading scores, but with ambition and eagerness to get what the course had to offer are the marked cases of growth and success. The study shows conclusively that the reward is directly proportional to the price paid in the way of real effort.

TABLE 5.

Correlation Between Final Mark of Junior College Physics Students and Certain Activities.

Correlation	Correlation Factor (r)
Final Mark vs. No. of Pages Read	.6818 ±.089
Final Mark vs. No. Problems Worked	.7221 ±.076
Final Mark vs. No. Hours per Week	.5261 ±.128

Conclusions. This study points to the following conclusions:

(1) Poor mathematical skill and ability possessed by the student at the beginning of the course does not preclude the possibility of success, nor does marked ability assure success.

(2) Physics offers a chance for corrective treatment of mathematical weaknesses. This may be self corrective very largely.

(3) While it is probably true that accuracy in reading and the ability to make correct inferences from reading matter is of value, the ability as found in average beginning classes is such that this matter is not vital. It is probable that deficiencies in these lines become self corrective in most cases.

(4) There seems to be no basis for the supposition that the student with much general science information will be more successful in physics than the student with small amount of general science information.

(5) It is probable that the intelligence tests are only a fair criterion of probable success in physics.

(6) Effort as measured by problem solution looms big as a factor of success in physics.

(7) The attitude of the individual is a potent factor of success.

(8) Extensive reading of reference material makes a large contribution to success.

(9) Time spent is not a criterion of success in physics.

RELATIVE PROMINENCE OF NATURAL SCIENCE AND MATHEMATICS SUBJECTS.

By S. Z. Scott,
Superintendent, Greene Public Schools, Greene, Ia.

A study recently completed was made for the purpose of determining the relative prominence of the subjects of study that have been offered in the secondary school programs of the state of Nebraska during the past two decades, 1903-04 to 1923-24. From the results of this study the following facts relative to the mathematics branches are worthy of note:

1. Algebra is apparently declining somewhat in its importance as an item in the curricula of Nebraska high school pupils.
2. The tendency during the past two decades has been to decrease the percentage of pupils studying three semesters of algebra.
3. A tendency is developing to offer four semesters of algebra in a number of Nebraska high schools.
4. The percentage of pupils studying geometry has had no material change.
5. Although still maintained in the program of studies, trigonometry has never attained a place of importance in the curricula of pupils.
6. Algebra and geometry are the prominent mathematics subjects included in the curricula of Nebraska high school pupils.

From the study of the science subjects the following conclusions are suggested:

1. The study of botany has shown a decrease in the past decade.
2. The study of chemistry has shown a gradual decrease.
3. During the last two periods studied, 1913-14 and 1923-24, physiology has maintained approximately the same status.
4. General science, which first appeared in the study in 1923-24, has shown extreme popularity for a new subject.
5. Physics still continues as a natural science subject of much importance.
6. During the past decade, agriculture has exhibited practically no change, regardless of favorable legislation in the Smith-Hughes Act.

THE USE OF THE UNIT-CONTRACT SYSTEM IN TEACHING BIOLOGY.

By Lynda Weber,
University High School, Madison, Wis.

Much interest is being manifested these days in the presentation of biological subject matter, as well as other subject matter, in clearly defined *units.* An equal amount of interest is being evidenced in the arrangement of the contents of the unit of work *so as to meet the abilities of individual pupil differences.* In this article, an attempt has been made to combine the two systems. For want of a better name, we shall call it the *unit-contract* system.

The unit of work chosen in this particular instance is one of great importance in the study of human biology, namely: *Selection of Foods.* In planning any unit, a teacher should have her *aims* clearly in mind at the outset. In this case the specific objectives are:

1. A knowledge and understanding of the underlying principles and facts.
2. Application of these principles to daily situations in life.
3. Establishment and rationalization of health habits.
4. Skill in scientific thinking—especially powers of observation, analysis, synthesis, independent reasoning, critical thinking.

A *pretest* has been worked out for the purposes of diagnosis and prognosis. It is essential for a teacher to ascertain how much the pupil already knows so as to determine where to start, and what is left to be accomplished.

A *presentation* outline has been developed in brief. It attempts to fulfill the following requirements:

1. To arouse interest.
2. To raise problems.
3. To provide guide-lines for further study.

The *assimilative material* has been developed by an outline of the subject matter that will lend itself to the development of the principles to be comprehended, and by a suggested list of available tools by means of which the required subject matter may be secured. The principles underlying the unit are *general;* the assimilative material is *specific.* The choice of assimilative material is based on availability, local interest, comprehensibility and social worthwhileness.

The *pupil activities* have been set forth in detail, outlining the development of the principles set down, and specifying the types

of scientific thinking involved in each step. The entire lesson outlines have been arranged on the three-level plan, the specific objectives being indicated for each level. All pupils are required to master the minimum essentials as outlined in the *fair* level contract. The work in the *good* level and *excellent* level contracts has been developed by (1) "the principle of extension through the quantitative approach; (2) the extension of materials by means of a qualitative extension, increasing the difficulty of subject matter and problems; (3) extension by enrichment."[1] More emphasis is laid on the last two methods than the first. "Every pupil is expected to work in the integrating contracts at those points where energizing is most productively exemplified;"[2] and "the contributions of each member of a working group will be appreciated by a process of linking together the productions created within the comprehension of the guide-lines."[3]

The *tests* used are not strictly of the objective type; but have been devised to determine whether the pupil understands the principles by his ability to apply them to new situations. All pupils take the same test at the end of the unit of work. It is evident, however, that pupils in the Excellent level will be able to answer the questions with a greater degree of accuracy, and with a finer and keener sense of understanding and appreciation than the pupils in the Fair level.

SELECTION OF FOODS.

Fair Level

I. *Sub-unit A.* Growth Producing Foods.
  1. Specific objectives.
  2. Assimilative material.

II. *Sub-unit B.* Health Regulating Foods.
  1. Specific objectives.
  2. Assimilative material.

III. *Sub-unit C.* Energy Producing Foods.
  1. Specific objectives.
  2. Assimilative material.

IV. Pre-test (written for Diagnosis and Prognosis covering the three sub-units A, B, and C.)

V. Presentation of Growth Producing Foods (A)

VI. Pupil Activity for A. (Detailed)

VII. Pupil Activity for C. (Detailed)

VIII. Test to determine Understandings of A, B, and C.

Good Level

IX. *Sub-unit D.* Well-Balanced Meals.
  1. Specific objectives.
  2. Assimilative material.
  3. Pupil activity. (In brief)

Excellent Level

X. Supplementary Problems and Projects.

Final Test (to be taken by *all* pupils).

[1]Miller, H. L., *Creative Learning and Teaching*, p. 66.
[2]*Ibid.*, p. 106.
[3]*Ibid.*, p. 107.

SUB-UNIT A.—GROWTH PRODUCING FOODS.

Specific Objectives.

A. *Knowledge* (health, worthy home membership.)
To attain this the following must be understood:
I. Growth is the change of non-living food material into new protoplasm and cells, thereby increasing the size of an organism.
II. New protoplasm and cells are produced from foods containing:
a. Nitrogenous substances.
b. Mineral matters.
III. Many of our common foods are growth producing foods, and can be classified into those rich in nitrogens, and those rich in minerals.
IV. Choice of such is necessary in our daily diet if growth is to be expected.
B. *Scientific Thinking* (Skill in)
I. Analysis.
II. Synthesis.
III. Critical thinking.
IV. Independent reasoning.
V. Application of principles to life-situations.

SUB-UNIT B.—HEALTH REGULATING FOODS.

Specific Objectives.

A. *Knowledge* (health, worthy home membership)
Understanding of:
I. Nitrogenous substances and mineral matter can be changed into new protoplasm *only* in the presence of vitamines.
II. Bulky foods are necessary for healthy teeth and healthy muscular activity of the intestinal walls.
III. Acid foods are necessary to counteract excessive fermentation in the intestines.
IV. Minerals are necessary to supply proper ingredients for the digestive fluids, and these in turn help to regulate digestion.
V. Choice of such foods is necessary in our daily diet if health is to be expected.
B. *Scientific Thinking*
(Same as for Sub-unit A.)

SUB-UNIT C.—ENERGY PRODUCING FOODS.

Specific Objectives.

A. *Knowledge* (health, worthy home membership)
Understanding of:
I. Energy (heat) is necessary to carry on the life-functions of an organism.
II. Energy (heat) is measured in calories.
III. The number of calories expended depends upon the surrounding temperature of an organism, and the degree of its bodily activity
IV. a. Energy is produced by the chemical combination of oxygen with carbon. This carbon is supplied by certain food-substances. (Review)
b. Fats, carbohydrates and proteins contain carbon in varying amounts.
V. Many of our common foods are energy-producing foods, and must be chosen according to their caloric values.
B. *Scientific Thinking.*
(Same as for sub-unit A.)

ASSIMILATIVE

Subject Matter.

A. I. Growth.

1. Structure of the cell—parts, uses. (Review)
2. Cell-divisions or growth
3. Evidences of growth
4. Regions of growth—plant, animal, human
5. Rate of growth

II. Classification of growth-producing substances.

1. Nitrogenous substances (necessary for *all* cells)
   a. Animal proteins
   b. Plant proteins
   c. Comparison of animal and plant proteins as to:
      (1) Assimilative values
      (2) Digestibility
      (3) Cost
   d. Amounts necessary—dependent on what conditions
2. Mineral substances (necessary for *special* cells)
   a. Most essential minerals needed in the body
   b. Uses of each in the body
   c. Value of minerals found in foods as compared with the same in tonics, etc.

III. Selection of common foods having a high percent of:

1. Protein content
   a. Animal
   b. Plant
2. Mineral content
   a. Iron
   b. Lime
   c. Phosphates
   d. Potash

IV. Practice in correct choosing of growth-producing foods

B. Will be indicated in *Pupil Activity.*

ASSIMILATIVE MATERIAL (SUB-UNIT C.)

Subject Matter

A. I. Energy (heat) is necessary to carry on the life-functions of an organism

1. Internal activity. Proofs—
   a. Comparison of temperatures of organs while at rest and while functioning
   b. Temperature of growing seeds as compared with non-germinating seeds
2. External activity.
   a. Increase of bodily heat increases with bodily activity (exercise)

II. Energy (heat) expended is measured in calories

1. A calorie is the amount of heat required to raise the temperature of 1 pint of water about 4 degrees F.
2. The number of calories required for the human body is determined by the calorimeter
3. The output and intake should balance

III. Number of calories needed under different conditions

1. Temperature
2. Age
3. At rest or sleeping
4. Exercise—various degrees of

IV. Calorie producing food-substances (Carbon)

1. Kinds—fats, carbohydrates, proteins
2. Number of calories produced by each—comparisons
3. Advisability or non-advisability of getting all calories from any-one kind

V. Ability to select foods containing the proper percentage of carbon in accordance with varying conditions

MATERIAL. (*Sub-unit A.*)

Tools.

............Microscope or lantern slide demonstrations—onion cells, elodea, etc.
............Diagrams and charts.
............Demonstrations—dividing paramecia, budding yeast cells, etc.
............Observation and experiment—measurement—young seedlings.
............Root-tips, stems, buds, young animal (weight). Height and weight charts for humans. Measurement of children.
............Texts and references.
............Charts.
............Bulletins (Experiment stations)

............Experimental reports.
............Experimental reports—table of time digestion.
............Daily price-list.
............Reference readings—dietetics books.

............Tests and references.
............Experimental reports.

............Reports from medical journals, pure foods laws, Gov't. reports.

............Experiments—food testing.
............Study of charts and tables.
............Books, charts, experimental reports.
.... " " " "
.... " " " "
.... " " " "
.... " " " "
............Study of personal menus—checking with standardized charts.

............Reference readings in physiology books.

............Experimental reports.

............Experimentation by individual pupils—seeds.

............Experiments by pupils.
............Comparisons of temperature of animals of varying degrees of activity. Readings.
............Reference readings. Explanations by teacher.

............Experiments—physical explanations and readings.
............Diagrams. Experimental reports.
............Hygiene (dietetic) magazines. Gov't. Health charts.
............Charts
............Reference readings.
............Experimental reports.
............Food charts.

............Charts.
............Reference readings.

............Experimental reports. Health clinic bulletins.

............Adapting standard menus to varying conditions. Study of personal menus under varying conditions.

PRE-TEST (PROGNOSIS AND DIAGNOSIS).

Written Test.

1. Your mother has taught you to drink milk with every meal—or perhaps the school-nurse makes you drink it here at school. Both tell you it makes you grow. What are the two main elements in milk that are necessary for the growth of your body, and what parts of the body are benefited by each? (Testing for growth-producing foods.)
2. If you play hard all forenoon, you undoubtedly will feel hungry by 10:30 and will go to your mother for "a bite to eat."
   a. Why does playing make you hungry?
   b. What would be the best kind of food for you to eat at that time? Why?
   (Testing for energy-producing foods.)
3. Your mother permits you to eat fatty pork in winter but not in sumer. Why?
   (Testing for energy producing foods.)
4. You are given acid fruits (such as orange, grapefruit, plums, etc.) every day in some form or other. Why? What do they contain that your body needs? (Testing for health regulating foods.)
5. a. Why does your mother insist that you eat lettuce or spinach frequently?
   b. Why is it better to eat whole-wheat bread than plain white bread?
   c. Why does your father say, "John, you must eat the *crust* of that piece of bread before you will be permitted to go out to play?"
   (Testing for health-regulating foods.)

PRESENTATION OF GROWTH-PRODUCING FOODS.

Start off the discussion with the following as a basis then permit the pupils' interests to further determine your method of procedure:

I. *Proteins*

I have here (preserved in glass containers—properly mounted) the embryos of young chickens in the various stages of development. The yolk contains the part of the egg which will start to develop into the young chick. (Point out formation of heart and other organs.) As this chick increases in size it needs food. Where does that food come from? Can you prove your statement by the study of these specimens? (Decrease in size of white of egg.) Last week we tested white of egg for food substances—what did we find? What, then, is necessary for the growth of the chick? What is going to supply the protein food substance after the chick is hatched? (After discussion has been led on to cereals)—Just why did the wheat plant store proteins in its kernel? (Food for young plant.)

If young animals and young plants need proteins, young humans also need it for growth. Start discussion along this line—raise questions which will leave before the class the following problems:

1. What forms of proteins are best for us?
2. From what foods do we obtain them?
3. How much do we need?
4. Do I eat the right kind and the right amount?

II. *Minerals*—(Suggestive of discussion work)

a. Show the difference between the bones of a young animal or human as compared with those of an adult.
   1. Pictures of misshapen skulls of certain islanders.
   2. Pictures of misshapen Chinese feet (women). How is it possible to obtain such results?
   3. Demonstrate the composition of young and old bones—have young and old chicken bones.

b. Why is it necessary for adult animals and humans to have harder bones?

c. What must we eat in order to supply materials necessary for proper bone-growth?

d. Am I getting the right substances for this purpose?

PUPIL ACTIVITY—GROWTH-PRODUCING FOODS.

I. *Growth*

1. Study demonstration microscopes of onion cells and elodea cells; also diagrams in references (indicate books and pages)—then work out the following outline:—(Supervision in organization is essential here.)

Observation
Analysis

Parts of a typical plant-cell:

A. Cell-wall.

Synthesis

B. Cell-body, etc.

Structure

Uses

2. Define cell, protoplasm, nucleus, cell-wall.

Drill on Conciseness

3. Study:

Demonstrations (Teacher)—

a. lantern projection microscope of cell division in onion root-tip cells.

b. Compound microscopes (2 or 3) of dividing paramecia.

Observation

c. Compound microscope of budding yeast plants.

Study references (pages indicated.)

(Purposeful—since definite questions must be answered)

4. Answer the following:

A. How is cell division accomplished? What is its purpose?

B. In the paramecian cell-division results in more individuals. Is this true in the yeast plant and in the root-tip? Explain.

Critical

C. What is meant by "No paramecia ever lost an ancestor by death."

Thinking

Teacher (1) Have on hand young growing seedlings. Call on pupil volunteer assistants to help mark off regions in different parts to determine where growth occurs, and also the rate of growth. (Have pupils follow teacher's directions or those of some good manual as Osterhart's.)

Interpretation — Application of principle.

Experimental work (directed).

(2) Others may collect buds (if in spring) and keep track of growth—collect buds at intervals and dip in paraffin to maintain size. Keep record of temperature as well from day to day.

Gathering adequate data

(3) Others may weigh young animals (pets) at various intervals.

Increasing concepts.

(4) Have on hand standardized height and weight charts—ask each child to measure his height and weight, and determine whether normal. Perhaps some of them recall their weight and height a month or so previous. Give reading references:

5. Answer the following:

a. Where are the main regions of growth in a plant? Of what advantages is it to plants to have them in these particular regions?

Critical thinking.
(Cause and effect)

b. From your observations or from botany references, collect at least 5 specific examples of rates of growth of different plants, or parts of a plant.

Verification.

c. Observe from the aquarium or in the open, or get from references (or use of both sources) the rate of growth of some form of animal—such as frog, fish, mammals, etc. How long till it is mature?

Gathering adequate data.

c. Find figures to show how fast the average human grows in height and weight at different ages till mature.

6. What is *growth?*

II. *Classification of growth-producing substances.*

Drawing conclusion on basis of adequate and accurate data.

The two essential food substances necessary for growth are nitrogenous foods, and minerals. Nitrogenous foods are essential for the growth of *all* cells; it builds up the protoplasm.

A. *Nitrogenous food substances:*

1. Study the following table—also read the references stated (give pages) and fill out the outline as indicated.

Analysis.

Nitrogenous food-substances are found in two forms, *animal* and *plant proteins.*

a. In general the animal proteins are the most efficient builders. Each day the child should have one of the following foods, which are rich in animal protein: milk, egg, meat, chicken, fish, cheese.

b. Vegetable proteins should be used to supply additional tissue-building food. They are abundant, less expensive, but generally not quite so efficient as the animal proteins.

Analysis.

c. The cereals, though consisting chiefly of starch, also supply 8 to 10% of proteins. The leading cereals are: oats, barley, wheat, rye, cornmeals, buckwheat.

d. Other foods rich in proteins are the legume seeds, such as: Soybeans, peanuts, Lima beans, lentils, dried peas, kidney beans, navy beans.

e. Still other foods are the nuts, such as: almonds, Brazil nuts, walnuts, beechnuts, hazel nuts, pecans, filberts.

Outline—(Using material from all references)

	Classes	Examples of
I. *Animal Proteins*	e. g. 1. Casein 2. Albumen, etc.	*Common foods containing each*
II. *Plant Proteins*	"	"

Synthesis by using cross-references.

2. Which of these two kinds of proteins is more efficient for growth? How many of our authors agree with this?	Verification Comparison
3. Which is more easily digested? Find the time of digestion for various kinds to prove your statement. (Give references.)	Verification Comparison
4. Which costs the more? Consult present price lists to prove your statements.	Verification Comparison
5. After answering the last three questions carefully, what are your *general* conclusions with respect to the use of proteins?	Drawing conclusions after sufficient verification.
6. Since proteins build up tissues, who should eat more, you or your father? Reasons.	Application of principle.
7. When do you need more, while attending school or while playing hard all day long?	Application of principle to life situation.
8. Under what two circumstances should an adult eat a larger amount of proteins than usual?	Stimulating (trying to) powers of suggestion.

B. *Minerals.*

1. From the following table, from charts on the walls and the references (post names of books and cite pages) work out the following outline: — Synthesis

Minerals (Main ones needed)	*Uses in Body*	*Common Foods in which found.*

Mineral matter, found in nearly all native food products, is necessary to build tissue, as muscle, bones, nerve, blood. Fortunately, most ordinary diets used in this country furnish the adult plenty of the various kinds of mineral matter. The four which are sometimes found in insufficient amounts are lime, iron, phosphate, and potash.

a. *Lime*—Found in milk and in milk products, in the yolk of egg, and in the leaves and stems of plants, especially in spinach, lettuce, cabbage, Swiss chard, celery, turnips, onions, dried figs.

b. The *iron* compounds—needed in building red blood. They are found in most abundance in the green-leaved vegetables, which are the least expensive source; to some extent in other vegetables and fruit, especially in dried raisins; in breakfast cereals made from the whole grain; in the yolk of egg, and in meat. The last two sources are expensive. — Analysis

c. The *phosphates*—milk is rich in phosphates. This is one reason why milk is the best food for the child. Other foods rich in phosphates are egg yolk, meat, vegetables, and breakfast cereals made from the whole grains.

d. The *potash* salts—abundant in tubers, such as the potato, and in the leaves of plants. They aid in regulating the body activity. In a varied diet they are always in abundance.

2. If you were anaemic would it be just as good for you to get the needed minerals through tonics? Why do doctors prescribe them? Look up in following references: (State some)

Critical thinking

Verification

III. *Selection of common foods containing growth-producing substances.*

1. From the available charts on food-contents, work out the following:

a. Pick out 8 or 10 foods that run very high in

1. animal protein	4. Lime
2. plant protein	5. phosphates
3. iron	6. potash.

Take down the percent in each case.

Analysis

b. Arrange them in their order of importance, placing those with the highest content first. Then learn them in that order. (6 or 7 of them)

Synthesis

2. Criticise the following food advertisements. Are they true, or are they exaggerated? Prove your answer in each case.

Independent reasoning

a. "Have you had your iron today?" Advertising raisins. How much iron have they as compared with other foods?

Critical thinking (don't take everything on faith)

b. "Banana—the muscle builder."

c. "Milk—the body builder."

Bring in 3 or 4 other food advertisements by tomorrow and analyze them.

IV. *Analysis of Personal Diets*

Analysis

Analyze each of the meals you ate today.

1. In which foods did you get a high percent of animal proteins? Plant proteins?
2. In which foods did you get each of the necessary minerals?
3. Did you get all the different body builders today? You know you should if you want to do justice to your own body.

Application of principles to life situations.

For the next week, pick out at every meal the foods that supply you with each of the required body-builders. If you realize you run short of any of them ask your mother to prepare certain foods that you know contain them, and tell your mother *why* you need them.

Attempt to establish habits of correct eating.

Educate the home through the schools (tactfully).

PUPIL ACTIVITY—ENERGY-PRODUCING FOODS.

I. *Energy is necessary to carry on the life-functions of an organism.*

1. Prove this statement by working out as many of the following as you can:

A. *Internal activity of organisms:*

a. Look up data in physiology texts to prove that the temperature of an organ in the human body increases during its active period (liver, brain, stomach, etc.)

Why do we feel warmer right after we have eaten a meal?
Why do you feel tired after a heavy dinner?

b. Experiment (performed by 2 or 3 in class)
Take about 20 or 30 pea seeds and place them in a tumbler with a small amount of water. Keep them in a moderately warm place. Fix another batch in the same way, but add a few drops of formalin. The formalin will kill the embryos in the seeds. Now wait until the seeds in the first tumbler have sprouted; then take a thermometer and take the temperature of each by placing the bulb of the thermometer down amongst the peas and leaving it there for 2 or 3 minutes before you read it. What is the difference? Can you explain this difference?

B. *External activities of an organism:*
   a. Prove (from any experiences you may have had) that exercise increases the bodily heat.
   b. Why are northern people more active than southern people?
   c. Do you think slow-moving animals have a different temperature than fast-moving animals? Try to find figures to bear out your supposition.
   d. If you have access to an apiary, compare the temperature in a hive filled with active, bees during the late forenoon with that of an empty hive, other conditions being the same.
   e. Can you prove in any *other* way that energy is necessary to carry on the life-functions of an organism either internally or externally? If so, report to the class to-morrow.
   f. Write a paragraph summing up concisely all the reasons you have found for believing energy (heat) is necessary to carry on the life-functions in an organism.

II. *Energy expended is measured in calories.*
   1. What is a calorie? Look up in references.
   2. Calorimeter. Balance of intake and output must be explained by teacher—use of diagrams, pictures, experimental reports, etc.
      Pupils to answer questions put to them during explanation and demonstration to make sure they comprehend; then give them a short written test to determine whether they understand what is meant by "the balance of intake and output."

III. *Calorie requirements under different conditions.*
   1. The number of calories needed depends upon the surrounding temperature; the age of the person, and the degree of bodily activity. Look up in references to determine how the requirements are changed by these varying conditions.
   2. After having looked up material on the above named points, be able to account for the variations in the following table:

Daily Calorie Needs (Approximately).

1.	For child under 2 years	900 Cal.
2.	For child 2-5 years	1200 Cal.
3.	For child 6-9 years	1500 Cal.
4.	For child 10-12 years	1800 Cal.
5.	For child 12-14 (woman, light work also)	2100 Cal.
6.	For boy (12-14) girl (15-16), man sedentary	2400 Cal.
7.	For boy (15-16) (man, light muscular work)	2700 Cal.
8.	For man, moderately active muscular work	3000 Cal.
9.	For farmer (busy season)	3200 to 4000 Cal.
10.	For ditchers, excavators, etc.	4000 to 5000 Cal.
11.	For lumbermen, etc.	5000 and more Cal.

   3. Study the following table. Write out at least 5 good thought questions referring to your daily life which will involve what this table signifies. (The best questions will be checked for you to ask the class tomorrow.)

Average Normal Output of Heat from the Body.

Conditions of Muscular Activity	Average Calories per Hour.
Man at rest, sleeping	65 Calories
Man at rest, awake, sitting up	100 Calories
Man at light muscular exercise	170 Calories
Man at moderately active muscular exercise	290 Calories
Man at severe muscular exercise	450 Calories
Man at very severe muscular exercise	600 Calories

4. Work out the heat output for a boy of 14 who spends 9 hours sleeping, 9 hours studying, 3 hours in moderately active muscular exercise, 3 hours awake (sitting up).
5. Work out your own output for today.

IV. *Calorie-producing food-substances.*

The heat (energy) required in the above problems is produced by the chemical combination of the oxygen we inhale with the carbon supplied by our foods. The food-substances that contain carbon are fats, carbohydrates and proteins.

1. These three food substances produce heat in varying amounts, depending upon the amount of carbon in each. Carbohydrates produce 4 calories per gram. Find out how proteins and fats compare with carbohydrates in this respect. Which do you conclude then, are the most efficient energy-producing foods.
2. Would it be advisable to get most of our calories from this source? From either of the other two carbon-containing foods? (Look up carefully in references and summarize your findings)

V. *Analysis of Personal Diets.*

(Directions same as in Growth-Producing Foods)

TEST.

The results of this test must prove that the pupil *understands* each of the three sub-units before he is permitted to go on with the G work. The foods chosen for analysis are those which are most common and most necessary for *health.*

In this type of test, the following requirements are made:

1. The pupil must be able to analyze specific foods.
2. He must have the ideas (organization and uses) of each subunit clearly in mind.
3. He must be able to fit the different component elements of the specific foods into the generalized scheme of No. 2.

		Growth-Producing Substances	Health Regulating Substances	Energy-Producing Substances
	Cheese	Animal Protein xx (Casein) etc.	Vitamine A x etc.	Fat xx Etc.
1	Orange			
2	Meat			
3	Milk			
4	Whole Cereal			
5	Spinach			
6	Egg			
7	Butter			
8	Green beans			
9	Peas or lima beans			
10	Tomatoes			

Directions for test: Fill in the above outline by taking each food, breaking it up into its various food-substances, and indicating whether such substance is a growth-producing substance, a health-regulating substance, or an energy-producing substance. For example, *cheese* contains animal protein (casein) which is a growth-producing substance; it contains vitamine A which is a health-regulating substance; it contains fat, which is an energy-producing substance.

Indicate the same as shown in the model below. If you want to indicate a small amount of any given food-substance, use one check mark; if you want to indicate a large amount, use two or three checks marks. These checks should indicate whether the food as a whole is mainly a growth-producing, a health-regulating, or an energy-producing food. It may be strong in two or even all three substances.

SUB-UNIT D—WELL-BALANCED MEALS.

Specific Objectives.

A. Knowledge (health, worthy home membership).
  To attain this the following must be understood:
  I. To have a well-balanced menu, each meal should contain some of each of the three classes of foods (mixed diet).
  II. To have a well-balanced menu, Calories should be supplied by fats, carbohydrates and proteins in standardized ratio during each day's menu.
B. Rationalization and Idealization of Habits of Selecting Foods.
C. Application of Principles to New Life-Situations.
D. Training in Seeing Work in Perspective.

ASSIMILATIVE MATERIAL.

I. Importance of mixed diets.
  1. Correct combinations of foods
  2. Analyses of various combinations of foods
    a. Correct (idealization)
    b. Incorrect (ability to detect mistakes.)
II. Caloric content in a well-balanced meal.
  1. Study of ratios (fats, carbohydrates, proteins) as determined by specialists. Reasons
  2. Acceptance of ratio suitable for American life
III. Analysis of pupil's diets (personal)
  1. Keeping track of day's menu and activity
  2. Determination of calories output for this day
  3. Thorough analysis of meals for this day to determine:
    a. Total number of calories—intake.
    b. Comparisons with out-put
      Balanced?
    c. Determination of ratio of Calories supplied by fats, carbohydrates, proteins
    d. Comparison with standard accepted
    e. Study of content with respect to growth-producing and health-regulating foods. Efficiency?
    f. Recognition of mistakes
    g. Correction of mistakes (on paper)
    h. Emphasis on dangers of these habitual mistakes
    i. Correction in *practice*. (If serious mistakes are found, pupils are asked to continue this analysis of their menus from day to day until they consciously have corrected their mistakes.)
IV. Daily diets of different types of people.
  Using one of the personal diets as a basis (Corrected form) Make modifications of this menu to suit the following types (Group-work)
  All three classes of foods to be considered.
  1. Healthy active child of 5 or 6
  2. Healthy active child of 10 or 12 (in school)

3. Healthy active child of 10 or 12 (during vacation)
4. Woman doing heavy house-work (house-cleaning)
5. Professional man (sedentary office work)
6. Professional man on vacation (hunting and fishing)
7. Student during examination week
8. Farmer in summer (harvesting)
9. Lumber-jack or ditch-digger in winter

V. Generalizations (Summary of Understanding)

(Note—Experience has shown that nearly every pupil will be able to finish the work in the Fair Level and at least through No. III of the Good Level. The rest of the work in the Good and Excellent Levels will be done by the more capable and ambitious pupils. The slower pupils will benefit from the work of the more capable pupils, because they have the foundation to understand the advanced work; and they will enter into the discussion work and solution of problems demanded by the High G and E group pupils in their reports and demonstrations.)

PUPIL ACTIVITY.

I. Mixed diets.

Analysis of *Ideal* combinations.
Analysis of wrong combinations—application of principles. (Reasoning by agreement and disagreement with standards learned through units A, B, & C)

II. Calorific content in a balanced meal.

Study of reliable scientists. Reasons for difference of standards in various countries.
Independent reasoning.

III. Pupil's diet.

Setting basis. Application of principle learned in C. (Sub-unit)
Idealization and rationalization of correct habits of eating.
(Supervision of individuals in this process)
Establishment of correct habits.

IV. Daily diets of types of people.

Application of principles to new life-situations.
Method: High G and E pupils group themselves (3 or 4) appoint their leader, confer and determine the method of approach to this problem. (Each group will work out the menu for one type of person.) Much worthwhile discussion occurs within each group which helps to develop leadership and cooperation. The menu is worked out, placed on the board, and the leader of each group presents the results to the entire class the following day. The differences between these menus are noted, and the explanation demanded of the Fair and Low Good group—if possible.

V. Generalizations.

Individual organization or class organization (pupil leaders.)

SUPPLEMENTARY PROBLEMS AND PROJECTS.

Specific Objectives.

Establishment and Rationalization of Health Habits.
Application of Principles to Life-Situations.
Critical Thinking
Organization
Research Reading.
Initiative
Leadership
(Individual supervision of methods in cases where necessary—individual initiative, however, is encouraged.)

Pupil Activity.

The projects are to be prepared and presented or demonstrated to the class. Liberal class discussion takes place, with the demonstrator as leader. Pupil critics are appointed, who must evaluate and criticize *constructively*.

Supplementary Problems and Projects.

1. Summer versus winter diet?
2. How many meals should we eat daily? What is the effect of eating between meals? (From the standpoint of amount.)
3. Analysis of food-content of a chocolate malted milk, "banana-split," or any other favorite "sweet-dish".
4. Underweight—causes—dangers—remedies?
5. Overweight—causes—dangers—remedies?
6. Importance of fruits in our diet? Kinds of most value?
7. Water and health.
8. Importance of green vegetables. Values of *canned* green vegetables. (Comparison) could we live on canned foods?
9. Outline the complete food content of sweet raw milk. Compare each of the following carefully (you may have to look up the process involved before you can determine the food content): pasteurized milk, skimmed milk, condensed milk, powdered milk, butter-milk.
10. Kipling said, "Comprest vegetables and meat biscuits may be nourishing, but what Tommy Atkins needs is bulk on his inside."
11. What is scurvy? Cause? Symptoms? Cure or prevention?
12. What is beri-beri? Cause? Symptoms? Cure or prevention?
13. What is pellagra? Cause? Symptoms? Cure or prevention?
14. What are rickets? Cause? Symptoms? Cure or prevention?
15. Report on very recent discoveries in connection with the study of vitamines.
16. What are vitamine tablets? Do you believe in getting your vitamines that way?
17. Avoid extremes of temperature in eating and drinking.
18. What is appetite? How can we educate a healthy appetite? Is it safe to follow one's natural appetite? What is the matter with so-called "food-cranks?"
19. What is the danger in over-eating in fats? Carbohydrates?
20. What is the danger in over-eating in proteins? Why have Arctic explorers subsisted on meats? What does the Eskimo eat? (Look up his diet, and preparation of meals.)
21. In what ways have modern methods of preparation of foods lowered the food content and values. In what ways have they increased the food values? Give examples (and proofs.)
22. If you were getting ready for a two week's camping trip in a place where you could procure nothing in the line of foods excepting milk, eggs, butter and perhaps fish, what foods would you take with you so as to meet all bodily needs?

Final Test.

1. It is 25 degrees above zero. Several of you expect to go on a long hike (15 or 20 miles) soon after breakfast. You will carry your lunch with you to eat out in the open (perhaps you'll build a fire). You'll return in the afternoon and eat your supper at home. Plan the whole day's meals so that they will meet the bodily requirements under the stated circumstances. State your reasons carefully.
2. a. Your father has been very ill with typhoid. He has, however, sufficiently recovered to be able to eat any kind of food. He is very much underweight. What foods would you advise him to eat? Why? b. Your little sister had her tonsils removed and lost a great deal of blood during the operation. What would you advise her to eat? Why?
3. What mistakes have you found you made in your selection of foods? If you *continued* to make the mistakes, what effect would they ultimately have on your system? What are you doing to correct your mistakes?

EQUIPMENT OF THE BIOLOGY LABORATORY IN A SMALL HIGH SCHOOL.*

BY E. V. KENNEDY,
Ava Community High School, Ava, Ill.

According to a report of the Commission on the Reorganization of Secondary Education, appointed by the National Educational Association, some of the aims in a course in Biology should be: "To develop the pupil's purposeful interest in the life of the environment by giving a first hand acquaintance with plants and animals.

"Train the pupil to observe life phenomena accurately and to form logical conclusions.

"Enrich the life of the pupil through the aesthetic appeal of plants and animals studied, to the end that he may appreciate and enjoy nature."

From a recent textbook on Biology, "Biology will take its place as a valuable subject in training only when teachers require accuracy in observation and the recording of these observed facts in suitable notebooks."

In recent years increasing emphasis has been placed on the study of living organisms. Physiological experiments and ecclogical studies have been introduced.

It is certainly true that as we attempt to understand nature we must not overlook the fact that the best place to study the plants and animals is in their natural habitat. It is comparatively easy to study plants and animals in their homes throughout the fall and in the spring but during the winter months what study is made of living things must be made in the laboratory. The large high school with a liberal allowance for the equipment of a laboratory, and some with access to a green house are not so seriously handicapped, but some small high schools with almost nothing but four walls, tables and chairs, find it hard to give the pupils first hand experience with living things. It is to those of this small type of high school that I am hoping this paper will be of some benefit.

For the past few years the project has been recognized as the obvious method for individual work and for group work by students as well. The assignment of projects to be worked out in a scientific manner greatly increases the value of laboratory work and needs add but little to the expense for equip-

*Read at the High School Science Section of the Illinois Academy of Science, April 29, 1927.

ment. The project method in Biology has not been adopted very generally in small high schools for two principal reasons: First, the necessity for economy; second, too rigid a standardization in laboratory equipment and supplies. This is due partly to requirements made by the State Department and Universities. The first of these causes can easily be eliminated, for as I have stated above the use of projects need not add to the cost of equipment. I will give in the following pages a number of projects carried out in our small high school, some individual and some group, with a very small cost to the school.

During the past two years we have studied in the laboratory the following living specimens: The Cecropia moth has been studied in the egg, caterpillar, cocoon, and adult moth stages. Other moths observed in the laboratory in the caterpillar, cocoon, and adult stages are, the Sphinx Deilephila lineata, and Phlegethontius carolina, Actias luna, Telea polyphemus, and Basilona imperialis. The Monarch butterfly has also been observed in three stages of its life cycle. The Anopheles mosquito has been observed and studied in the egg, larva, pupa and adult stages. The students watched with much interest the development of the mosquito through each of these stages. This animal is particularly interesting to Southern Illinois since about 60% of the malaria of the state was found in twelve counties of Southern Illinois during the years 1922-23 and 24.

Crayfish have been kept throughout the whole school year and we have watched them pass through three molts. The leopard frog has been watched through egg cleavage, blastula and gastrula stages, the tadpole and adult frog. We have kept the common mussel and studied its movements and methods of obtaining food. We have studied the hydra, planaria, water snail, amoeba, paramoecium, and vorticella.

We have grown and observed the following plants: tradescantia, red, variegated, and green species for studying typical closed veination, and effect of chlorophyll in photosynthesis; corn for the study of a typical monocot stem and leaf; ice plant for studying function of epidermis; beans for studying region of elongation of stems; geraniums for study of typical structure of a leaf and several other plants for various experiments.

All these plants and animals have been kept in the laboratory throughout the school year and pupils have had first hand experience in studying their structure, life history and habits. The total cost of equipment necessary for keeping the above

named living specimens amounted to less than five dollars.

An insect cage for hatching and rearing moths and butterflies was made from an orange case donated by a grocer. The two ends of the cage made excellent top and bottom to the cage. These were connected by four upright pieces 1 by 2 inches and 30 inches long. Then the three sides were covered with wire screening at a cost of 25 cents. The back was made into a sliding door.

Two window boxes each 4 feet by 1 foot and six inches deep were made from choice cypress and given four good coats of paint. They were placed in south windows on brackets. The total cost of the window boxes was $2.50.

Thirty cents' worth of pine lumber made a shelf in another south window 4 feet by 2½ feet capable of holding ten or twelve eight inch flower pots.

Our aquarium was made of clear cypress 1 inch by 8 inches. The inside dimensions were 1 foot by 4½ feet and 8 inches deep. This was lined with galvanized tin and carefully soldered. The outside was given two coats of paint. With a shallow layer of sand, gravel and small rocks, this made a comfortable home for frogs, mussels and crayfish.

Stretching boards for mounting insects were made from ½ inch pine board 3 inches wide.

This equipment is listed in a science catalogue at $25.00 and may be made by the pupils themselves for $4.80.

There are lists of standard equipment prepared by scientific companies, State Departments and universities, but all of them contain a large number of articles that a small high school can well get along without. The following equipment is sufficient for a high school whose classes in Biology are not larger than twelve students:

3 compound microscopes
6 magnifiers
4 ring stands with rings
6 dissection sets
1 section razor
1 hand microtome
6 test tube brushes
6 dissecting pans
2 dozen test tubes
6 battery jars
3 tables (these may be made by local cabinet maker or carpenter)
½ dozen cover glasses
1 dozen pipettes
6 watch glasses
6 evaporating dishes
1 nest beakers
1 thermometer
1 100 cc graduate
6 feet of rubber tubing ¼ in.
filter paper
glass tubing ⅛ to ¼ inch
6 dozen glass slides

Chemicals.

100 cc eosin
10 grams iodine
1 lb. ammonium hydroxide
1 gallon alcohol

1 pound ether
1 pound nitric acid
1 pound sulphuric acid
1 pound hydrochloric acid
1 gallon formalin
50 grams glycerine
1 pound chloroform
2 lbs. Fehling solution No. 1
2 lbs. Fehling solution, No. 2

Another valuable part of the laboratory equipment is the collection of the real things of the natural world, and the preserving of them in the laboratory. Our laboratories may be literally filled with materials that will aid in arousing interest in Natural Science and this is one of the chief ends of the study of Biology.

It is altogether possible to make our laboratory a center of community interest. The interest created in the student will soon spread to members of the community and all will join in acquiring some most interesting material.

REPORT ON SCIENCE CURRICULA.

For several years the North Central Association of Colleges and Secondary Schools has had at work a large committee on the revision of the secondary school curriculum. The work of the committee is rapidly nearing completion and there have already been published the reports of several of the sub-committees. The reports on science, covering general science, biology, chemistry and physics are available as a reprint from C. O. Davis, Ann Arbor, Michigan (University of Michigan).

The report of the sub-committee on mathematics is published in the March *Quarterly*, 1928, and is available from the same person.

The curricula for all the high school subjects are treated in the same way. The generally accepted objectives of the N. E. A. Committee on Secondary Education are used in a slightly modified form. These, health, citizenship, wise choice of and efficiency in a vocation, etc., are taken as the basal objectives. Curriculum material, in part organized in units, is presented with a view to the achievement of these objectives. The work outlined is largely in qualitative form though a few bits are quantitatively expressed to indicate the sort of thing that still needs to be done.

There are presented here some brief excerpts from the report of the science committee just to show the character of the work that has been done.

2. Knowledge Which Functions Directly in Developing Dispositions and in Discovering and Developing Abilities.

a. Knowledge of the lives of great physicists.

Illustrative material:

James, Henry, French Poets and Novelists. (Lives of the two Amperes —pp. 153ff.)

Fahie, J. J.—Galileo, his Life and his Work.

Heath, Sir Thomas, The Copernicus of Antiquity (Anstarches of Samos).

Potamian and Walsh—Makers of Electricity.

Crowther, J. A.—The Life and Discoveries of Michael Faraday.

Arago, Francois—Biographies of Distinguished Scientific Men. (Arago's own autobiography is also included.)

Bryant, W. W.—Galileo.

Hart, Ivon B.—Makers of Science.

Wheatham, W. C. D.—Cambridge Readings in the Literature of Science.

The Pneumatics of Hero of Alexandria (translated from the original Greek filled with illustrations of experiments of somewhat magical nature for that time with vacuums. Very simple language.

Physics has a wealth of materials of a most interesting nature of descriptive and biographical materials like that illustrated above. The Committee cannot attempt here an exhaustive list.)

B. Developing Attitudes, Interests, Motives, Ideals, and Appreciations.

Illustrative material:

Bragg, W. H.—The World of Sound.

The books found in the Romance of Science Series printed by the Society for Promoting Christian Knowledge.

For example—

Boys, C. V.—Soap Bubbles—Their colors and the forces which mould them (being a substance of many lectures delivered to juvenile and popular audiences).

Darrow, Floyd L.—Masters of Science and Invention.

(The Committee has not analyzed physics in the light of the social objective due to the fact that the unspecialized vocational objective and the leisure time objective considerably overlap the social objective.)

II. FROM THE STANDPOINT OF THE VOCATIONAL OBJECTIVE.

A. Acquiring Fruitful Knowledge.

1. Preparatory to Acquiring Other Knowledge.

Illustrative material:

Knowledge of a limited number of elements, with their compounds commonly used in the industries and in the ordinary occupations of life These may include aluminum, copper, silicon, zinc, tin, etc.

A limited number of typical bases and acids, and the simpler aspects of neutralization and formation of salts.

Simple aspects of valence and combining weights of elements.

Situations to develop facility in use of simple chemical equipment.

2. Knowledge Which Functions in Developing Dispositions and Abilities.

Illustrative material:

Study of vital dependence of our industrial life and prosperity upon science of Chemistry, with examples from history of modern industrial nations.

Study of dependence of specific industries, or occupations, upon chemical science, as agriculture, medicine, engineering, transportation, homemaking, mining, etc.

3. Knowledge Useful in the Control of Situations of Every Day Life.

Illustrative material:

Problems involving understanding of phenomenon of combustion, and knowledge of calorific values of common fuels.

Problems and situations requiring knowledge of cleansing compounds and proper use of same.

B. Developing Attitudes, Interests, Motives, Ideals, and Appreciations.

Illustrative material:

Problems from life involving the functioning of specific ideals as to maximum efficiency in combustion of fuels, selection of clothing, etc.

C. Mental Techniques in Memory, Perception, Imagination, Judgment, and Reasoning.

Illustrative material:

Problems involving judgment as to relative values of fuels for specific purposes, as crude oil, coal, coke, etc.

Problems involving selection and purchase of fabrics and clothing.

Problems involving selection and purchase of range or furnace for efficient combustion of fuel.

Problems involving selection and purchase of household appliances, tools, etc.

D. Right Habits and Useful Skills.

Illustrative material:

Problems and situations to develop ability to regulate range and furnace or automobile engine to secure maximum efficiency.

Problems to develop ability to remove stains, dirt, etc., from fabrics, metal, wood, glass, etc.

The whole task is an ambitious one and since it has been accomplished by a combination of high school principals, school superintendents, teachers in the various fields, and experts in the pedagogy of the subjects, the result should be a very practicable curriculum. The committee does not flatter itself with the belief that the proposed curriculum is a final solution of the problem. It does believe, however, that the thoroughgoing and honest effort at a curriculum for secondary schools, revised on a uniform plan, is a long step in advance.

A SPIRITED CONTROVERSY IN FRANCE.

In putting before Parliament his innocent-looking proposal to make secondary education free, as primary education long has been, Edouard Herriot, Minister of Public Instruction, has brought both subjects suddenly into the realm of current political issues—the schools directly, the Church indirectly.

M. Herriot has expressed the desire "to replace the idle sons of the rich by the laborious sons of the poor among the 150,000 pupils in the secondary schools." He would not, presumably, bar the studious sons of the rich, nor would he favor the idle sons of the poor; rather would he make scholarship and not wealth the basis of entrance into the privileged and limited class of those enrolled in what correspond, broadly, to American high schools.

The fact that there are only 150,000 pupils enrolled in the secondary schools in a nation of 40,000,000 indicates how small is the proportion of young Frenchmen who partake of the benefits of higher education. There certainly are many more who merit further training than that of the free primary schools, which the pupil usually finishes at the age of 13.—From *The New York Times*.

A PROJECT IN COMMERCIAL GEOGRAPHY.

By J. R. Schindler,
Central High School, Detroit.

Each member of the class chose a commercial product or an industry of international significance about which to secure and organize information and materials. The topics chosen included: Airplanes, Aluminum, Automobiles, Books, Brick, Canning, Carpets and Rugs, Cement, Citrous Fruits, Clothing, Coal, Cocoa, Corn, Cotton, Dairying, Fertilizers, Fishing, Flax, Floriculture, Fruits, Furniture, Furs, Glass, Gold, Herding, Irrigation, Iron and Steel, Jewelry, Leather, Lumbering, Meat Packing, Mining, Movies, Paints and Varnishes, Paper, Petroleum, Radios, Railroads, Rice, Roads, Rubber, Salt, Shoes, Silk, Spices, Steamship Lines, Stone, Sugar, Tea, Tin, Tobacco, Vegetables, Water Power, Wheat, Wool.

The sources from which the students drew included encyclopedias, books, magazines, government bulletins, trade journals, newspapers, advertisements, correspondence and interviews with people engaged in the industries, as well as visits to industrial plants. On the average each student secured material from twelve different sources. The materials included clippings, pictures, advertisements, and specimens.

The organization of this information and material was left to the individual student and depended largely upon the nature of the subject. Very frequently, however, the arrangement followed this outline: Origin, history, raw materials, methods of production, methods of manufacturing, centers of production, varieties, distribution, uses, social influences, current conditions, and future.

Each prospectus contained at least one map and one graph. The clippings, pictures, and specimens were mounted and distributed at appropriate intervals throughout a blank book. Each prospectus had its table of contents, bibliography, and list of acknowledgements. The reading matter was written, lettered, or typewritten. All prospectuses were bound within appropriate covers, and a few had decorations and drawings in water colors.

Through this project the student accumulated a wealth of information regarding a commercial activity in which he was interested. He became familiar with methods of research, he was brought in direct contact with the business world, and he was called upon to exercise initiative, originality ingenuity, patience, and skill in order to bring his project to successful completion. Frequently light was thrown upon the student's vocational aptitudes and interests.

The business houses solicited were generally pleased by the interest displayed in their activities and responded by extending many courtesies to the students and, in several instances, by offering employment to the information-seeking boys and girls. One prospectus was submitted to an advertising agency. It was accepted and published.

This project has been carried out by the classes in Commercial Geography at Northern and Central High Schools, Detroit, each semester for the past seven years.

Twenty days of sick leave each year are allowed teachers in Saskatoon, a city of Saskatchewan Province, Canada. The sick leave amounts in 10 years to a school year; and if unused for that purpose, the teacher may take a year's leave of absence and receive 60 per cent of the salary, provided at least half the year is spent in study and self-improvement.

CAUSE OF LOST APPETITE.

Parents with offspring that have to be forced to eat will be glad to know that scientists are on the trail of the reasons back of lack of appetite.

Prof. J. C. Drummond, well-known vitamin specialist, and Dr. S. K. Kon of University College, London, have found that there is a close relationship between the amount of vitamin B in the diet and the total amount of food taken. Pigeons fed a diet adequate in all respects except that it lacked vitamin B lost all appetite for the meals presented to them. Another group of pigeons kept under observation as controls, fed as much food as they wanted along with an ample ration of vitamin B grew healthily and retained normal appetite. A third group, fed only, the amount of food that the first group actually ate plus a plentiful supply of the vitamin in question, showed loss of weight due to slight starvation.

From their results, Professor Drummond and Dr. Kon concluded that the loss of weight that is always associated with lack of Vitamin B is simply caused by partial starvation; the pigeons lose their appetites and refuse to eat the deficient food, and hence lose weight.

Since vitamin B occurs in only minute quantities in different foods, its presence becomes of increasing importance. Consequently, an elaborate study of this question has been taken in hand at the Chemical Department of St. Thomas' Hospital Medical School, London, by Dr. R. H. A. Plimmer and his colleagues. They tested a number of cereals by feeding them to pigeons for a long period. They found that none of the cereals examined contained such a rich amount of vitamin B as dried yeast. Wheat, barley and rye contained more vitamin B than maize or oats. These investigators, like Professor Drummond and Dr. Kon, found that young animals need more vitamin B than adults, and that the first important symptom is loss of appetite, which leads to loss of weight. —*Science News-Letter.*

SCIENCE QUESTIONS.

CONDUCTED BY FRANKLIN T. JONES.

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Send all communications to my home address—Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio.

A QUICK QUESTION STIRRETH UP INTEREST.

The State of Iowa, town of Hawarden, stands first in answering SCIENCE QUESTIONS from the March number of SCHOOL SCIENCE AND MATHEMATICS.

512. *The Physics Class of the Hawarden High School through their spokesman, Lloyd Knox, send the following letter.*

"The Physics Class wish to ask you what the latest developments of the 'Theory of Magnetism' are.

"In your reply, please relate as to some sources where the material could be found.

"Your advice as to this matter would be appreciated very much."

Answer by the Editor.

The most recent statement on the "Theory of magnetism" available on short notice is found in "GENERAL PHYSICS" by Professor Henry Crew of Northwestern University on pages 398 to 403. (The Fourth Edition was published by the Macmillan Co. in 1927.)

He says—"We have had, since 1905, a sketch which, in its main outlines, nearly everyone believes to be correct. At any rate, this modern theory which we owe to the French physicist, Langevin, has greatly simplified the whole subject." (He then outlines the *molecular theory of magnetism.)* . . . .

"Immediately after the discovery, in 1820, that every electric current is accompanied by a magnetic field of its own, Ampere suggested that the reason certain elements are magnetic is that their molecules or atoms have electric currents flowing about them in minute circuits; and no reason has ever been discovered for abandoning Ampere's viewpoint." . . . .

"In 1876, Professor Rowland showed by a justly celebrated and difficult experiment that a revolving electric charge produces the same magnetic effects as an electric current. In 1897, J. J. Thomson demonstrated the existence of small electric charges which are negative in sign and can be obtained from any element in Mendelejeff's Table. They are called *electrons.* Accordingly the present view (1926) of an atom is that it is built up, in part at least, of a number of electrons in rapid rotation about a central nucleus of positive electrification. Each of these electrons moving in its orbit is equivalent to a minute magnet. . . . . . "

Another reference on this subject, available to all, is the Eleventh Edition of Encyclopedia Britannica, Volume 17, in the article Magnetism, under the "Molecular Theory of Magnetism," pages 350-251.

Readers are asked to suggest other articles on the subject.

Is there anything more recent than the above?

ANOTHER QUESTION.

513. *Proposed by Sudler Bamberger, Harrisburg, Pa.*

A falling body moves through such a great distance we must take the variation of g, the acceleration of gravity, into account. Since the formulae for freely falling bodies will be inapplicable, find formulae that are.

SIR ISAAC NEWTON.

Two hundred and one years ago Sir Isaac Newton died (March 20, 1727). "The discovery of universal gravitation is the discovery of the law of universal order, which is the basis and essential character of all sciences. . . . . We repeat the inscription on the Westminster Tablet which was erected in 1731:

LET MEN REJOICE
THAT SO GREAT A GLORY OF THE HUMAN RACE
HAS APPEARED.

. . . . Newton's greatest achievements lay in overcoming many mathematical difficulties and establishing the laws of gravitation and of motion known by his name." In SCIENCE, March 9, 1928 (pp. 255-262), will be found the minutes of the "Commemoration of the Bi-Centenary of the Death of Newton."

Why should not schools, and classes in science in our schools, commemorate the anniversaries of such great scientists!

SOLUTIONS AND ANSWERS.

509. *Original problem submitted by Charles Woolley, Ridgewood High School, Ridgewood, New Jersey.*

A boy on a train moving at the rate of 45 miles per hour plays a stringed instrument. A string a meter in length and 1½ mm. in diameter vibrates 380 times per second, the temperature being 77°F. If the string be made 500 mm. in length and 3 mm. in diameter, at the end of 2 seconds a note corresponding to how many vibrations per second will reach the listener who watches the train approach?

Solution by the Proposer

1. No change in vibration rate of string.
2. 45 miles per hr. = 66 ft. per sec.
3. 77°F = 25°C.
4. Velocity of sound at 25°C = 1140 ft. per sec.
5. 3′ = wave length.
6. 22 more pulses reach ear at end of a second.
7. 44 more pulses reach ear at end of 2 seconds.
8. 424 vibrations *(answer).*

TO SCIENCE TEACHERS.

Have you appointed a Boswell? (See the March number of SCHOOL SCIENCE AND MATHEMATICS, p 310.)

Why Not? The boys and girls at Hawarden, Iowa, found something that they wanted to ask about. Perhaps yours would like to do the same.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

LATE SOLUTION.

986. *E. de la Garza, Brownsville, Texas.*

SOLUTIONS OF PROBLEMS.

996. *Proposed by the Editor.*

If $8x = \log_e 3$, prove that

$$\tan 15° = \frac{e^{2x} - e^{-2x}}{e^{2x} + e^{-2x}}.$$

Solved by S. A. Francis, San Mates Jr. College, Calif.

$e^{8x} = 3$, and $e^{4x} = \sqrt{3}$. Tan 15° = tan(45° − 30°).

Hence $\tan 15° = (\sqrt{3} - 1)/(\sqrt{3} + 1) = (e^{4x} - 1)/(e^{4x} + 1)$.

Multiplying the terms of the last fraction by e^{-2x} we get the required result.

Also solved by *P. H. Nygaard, Roland Smith, Ernst Quinn, Spokane, Wash.; Franklin A. Butter, Jr., San Jose, Calif.; J. T. Rossen, Burlington, Iowa; J. F. Howard, San Antonio, Texas; Tillie Dantowitz, Philadelphia, Pa.; Robert Cashman, Bethany, W. Va.; Smith D. Turner, Cambridge, Mass.; R. T. McGregor, Elk Grove, Calif.; Raymond Huck, Shawneetown, Ill.; G. H. Crandall, Culver, Ind.; J. Murray Barbour, Aurora, N. Y.; Sudler Bamberger, Harrisburg, Pa.; Nelson L. Roray, Metuchen, N. J.; Harry E. Williams, Ironton, Ohio; Besse Hartung, Lester Gallett, Everette LaDuke, Theodore A. Miland, Milton Haunschild, Louise M. Pederson, Eau Claire, Wis.*

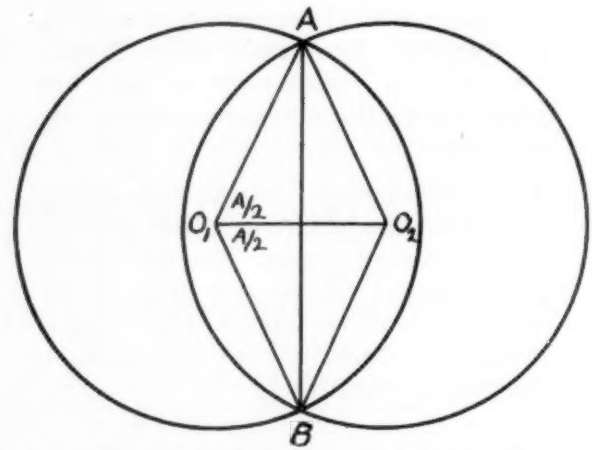
997. *Proposed by A. J. Patterson, Wheeling, W. Va.*

Two equal intersecting circles, radii 4, mutually bisect areas. Find the distance between the centers.

Solved by R. E. Morris, Spokane, Wash.

The area of the segment subtending $\angle AO_1B$ is

$$8(A - \sin A) = 4(\text{pi}).$$



By trial one finds that A = 132°20′36″. Hence the length of O_1O_2 = 8 cos 66°10′18″ = 3.232.

Also solved by *Nelson L. Roray, Metuchen, N. J.; P. H. Nygaard, Spokane, Wash.; J. Murray Barbour, Aurora, N. Y.; Smith D. Turner, Cambridge, Mass.;* and *George Sergent, Tampico, Mexico.*

998. *Proposed by the Editor.*

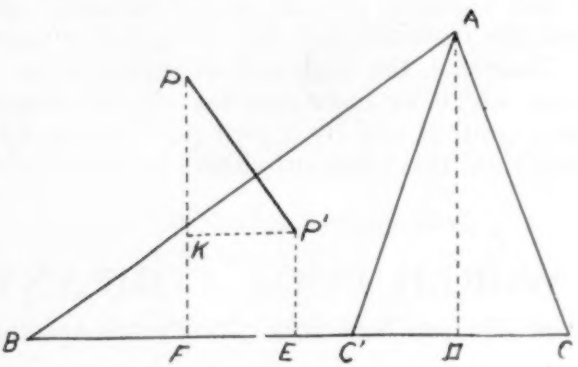
In the ambiguous case, given B, c, b, if a_1, a_2 are the two values of a, prove

I. The distance between the centers of the circumscribing circles of the two triangles is $(a_1-a_2)/2 \sin B$.

II. If $B=45°$, the angle between the two positions of b is arc cos $[(2a_1a_2)/(a_1^2+a_2^2)]$.

Part I. *Solved by G. N. Crandall, Culver, Ind.*

Let P′ be the center of the circumcircle of triangle ABC, and P the center of the circumcircle of triangle ABC′.



$BE = a_1/2$, and $BF = a_2/2$. $FE = (a_1-a_2)/2$.

$\angle P = \angle B$. $KP' = PP' \sin P = PP' \sin B$. Hence

$PP' = KP'/\sin B = (a_1-a_2)/\sin B$.

Part II. *Solved by Smith D. Turner, Cambridge, Mass.*

Editor. The notation refers to the figure for the solution of *Part* I.

Draw AD $\perp$ to BC. Then $BD = (a_1+a_2)/2$ and $DC = (a_1-a_2)/2$.

$\text{Cos } C'AC = \cos 2(DAC) = (2\cos^2 DAC - 1)$. But $\cos DAC = AD/AC$, and $(AC)^2 = (AD)^2+(DC)^2$. Since $\angle B = 45°$, $AD = BD$. Then

$$\cos C'AC = \frac{2(AD)^2}{(AD)^2+(DC)^2} - 1 = 2a_1 a_2/(a_1^2+a_2^2).$$

Also solved by *Nelson L. Roray, Metuchen, N. J.; Tillie Dantowitz, Philadelphia, Pa.; George Sergent, Tampico, Mexico; J. F. Howard, San Antonio, Texas; R. E. Morris, Spokane, Wash.;* and *Sudler Bamberger, Harrisburg, Pa.*

999. *Proposed by R. T. McGregor, Elk Grove, Calif.*

Show that the centers of the four circles circumscribed about the triangles formed by four straight lines are concyclic.

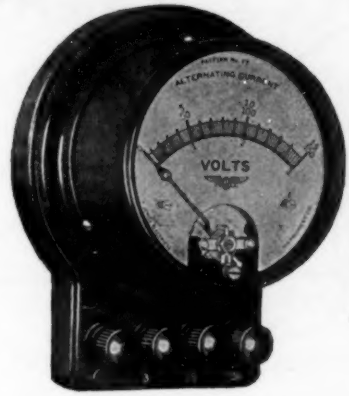
Solved by George Sergent, Tampico, Mexico.

Let ABC be the triangle formed by three straight lines, and D, E, F, the points where the fourth line cuts BC, AC, AB.

Let O, P, Q, R be, respectively, the centers of the circles about ABC, AEF, BDF, and CDE. By *Miquel's Theorem*, these circles have a common point, S.

The center line OP is $\perp$ to SA, common chord of circles O and P. Similarly, OR is $\perp$ to SC, PQ $\perp$ to SF, and QR $\perp$ SD. The arcs ASC, in circle O, and DSF, in circle Q, are similar, subtending the same angle ABC = angle DBF. Hence, $\angle$POR, measured by one-half of arc ASC, is equal to $\angle$PQR, measured by one-half of arc DSF. Therefore O, P, Q, and R are concyclic.

Editor. This theorem has been proved in the February, 1926, issue. Some interesting references may be found relative to the history of this problem.



Pattern
No. 77
Triple Range
A. C. Laboratory
Voltmeter

An Instrument For Individual Student Use

Pattern No. 77, although a very fine instrument for general alternating current measurements, finds extreme usefulness for student experiments in school laboratories where the increasing importance given to the study of alternating current requires an accurate but inexpensive instrument for individual student use.

This style instrument is an original Jewell design and is considerably larger than similarly appearing competitive instruments, thereby affording very definite advantages in its use.

The workmanship is of high perfection, giving a degree of accuracy not ordinarily found in an instrument of this type. The rugged and durable construction is an assurance of a generous capacity to withstand an unusual amount of abuse.

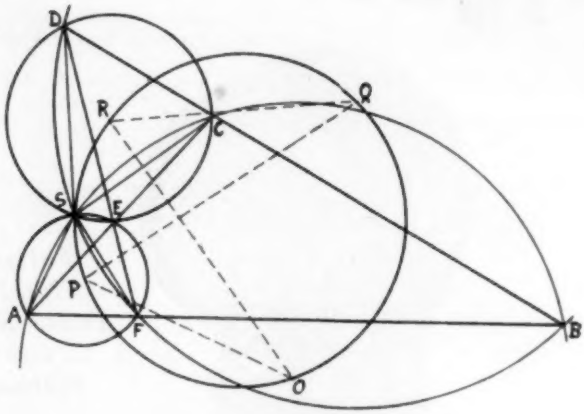
Pattern No. 77 may be obtained as single range ammeters of any range from 20 milliamperes up to 40 amperes; as single range voltmeters from 5 volts up to 150 volts, and in several double and triple ranges, including the 0-3-15-150 volt instrument illustrated.

Principal scientific supply houses throughout the United States are in a position to give prompt service and information on Jewell instruments. In addition, a new Jewell catalog, No. 16, gives the very latest and most complete listings of all Jewell instruments, including the Pattern No. 77, and will be forwarded upon request.

"28 Years Making Good Instruments"

Jewell Electrical Instrument Co.

1650 Walnut St., Chicago



Also solved by *Bessie Green Andrews, Wichita, Kansas.*

1000. *Proposed by E. de la Garza, Brownsville, Texas.*

The actual age of a person is equal to the sum of the digits of the year of his birth. Find the age.

Solved by Robert Weaver, Spokane, Wash.

The person must have been born in either the 19th or the 20th century. However, the largest sum of the digits of any year in the 19th century is 27, this being the sum of the digits of the year 1899. In 1928 the person is 29 years old if born in 1899. The maximum sum of the digits being 27, and the minimum number of years between the 19th century and now being 29, no year in the 19th century will satisfy the conditions.

Let x be the ten's digit and y the unit's digit for the year of birth, and z the present age. Then

$$10x+y+z = 28$$
$$10+x+y = z,$$

from which set of equations we get $y = (18-11x)/2$. Since x, y and z must be integers, I may assume values for x from 0 to 9. 0 is the only value of x which makes y a positive integer. Hence $y = 9$, and $z = 19$ the required age.

Also solved by *Tillie Dantowitz, Philadelphia, Pa.; John F. Green, Spokane, Wash.; Martin Berlin, Monte Vista, Col.;* and the *Proposer.*

PROBLEMS FOR SOLUTION.

1013. *Proposed by E. de la Garza, Brownsville, Texas.*

Show that the area of a right triangle is equal to the product of the segments determined on the hypotenuse by the inscribed circle.

1014. *Proposed by George Sergent, Tampico, Mexico.*

A given hemisphere, of radius 1, is cut into two equivalent volumes by a plane parallel to the base. What is the distance from the center of the base to the plane? (Archimedes' Problem.)

1015. *Proposed by Orville Barcus, Columbus, Ohio.*

Show that all numbers of the form $\left(2^{2^{12n+2}}+4\right)$ are divisible by 13 and 53, when n is an integer greater than zero.

1016. *Proposed by P. H. Nygaard, Spokane, Wash.*

Prove that the following expression is approximately true for small positive or negative values of d:

$$\log_e(N+d) = \log_e N + \frac{d}{N+d/2}$$

1017. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

If the polar of the center of one circle with respect to a second circle coincides with the polar of the center of the second circle with respect to the first circle, the two circles are orthogonal.

1018. *Proposed by E. de la Garza, Brownsville, Texas.*

One of my customers returned 815 lb. of coffee at 13½ cents per pound and bought 865 lb. of coffee at 18½ cents per pound, paying in cash for the difference. I told him he had to pay the difference of price (5 cents per pound) on 1000 lb. of coffee. Prove algebraically (a) that I was right, and (b) that this and similar problems can also be solved by a simple addition.

TESTING METAL WITH RADIUM.

Using radium rays so penetrating that they can go through pieces of 15-inch metal to test for hidden flaws in large castings is one of the latest accomplishments of the Russian State Radium Institute at Leningrad.

These "gamma rays," as they are called, are similar to X-rays, but are of much shorter wave length. They are more penetrating and can pass through pieces of metal too thick to be examined with the X-rays. Examination by radium is said also to be cheaper than with X-rays, because the same radium can be used over and over for an indefinite time. Large and expensive photographic plates are not required, since the rays, after passing through the object, act upon a special, sensitive electroscope. The test record is preserved for future reference in the form of a simple diagram automatically traced. Another advantage is that gamma rays speed up the inspection—it may be cut down to a couple of minutes for a large casting—while X-rays require a very long exposure, often of several hours, when metal is more than two or three inches thick.

The apparatus, as developed by the Russian scientists, is very simply constructed. A tiny glass capsule with a radium preparation is inserted into a deep hole bored in a large lead ingot. This stops all rays, except a narrow strong beam that goes along the bore. This beam pierces the casting and encounters two filaments charged with electricity and enclosed within a copper cage. There is an air space between the filaments and the cage which act normally a perfect insulator, allowing no electric current to pass through it. But as soon as gamma rays have a chance to get in the cage they ionize the air and turn it into a conductor.

Electricity, from a battery, flows from the filaments to the copper cage and from it passes through a galvanometer and back to the battery.

As intensity of the rays changes with thickness of metal pierced by them, the rate of ionization varies accordingly. Therefore the flow of electric current exactly mirrors the shape of the object under test. Any deviation at once shows that some imperfection is present.—*Science News-Letter.*

Volume One, Number One of "The Laboratory," the new house organ of the Fisher Scientific Company, appeared a few days ago. It "will pursue with great interest new scientific apparatus and act as historian to this ever evolving laboratory growth." It is a well-edited little journal chuck full of interesting items. Its chief business is to make the name Fisher better known and to promote the interests of the company but this will be done by serving students and teachers of science. Many teachers have discovered that the various scientific catalogs and other publications of the scientific instrument and supply companies are often the most valuable references.

BOOKS RECEIVED.

College Algebra by Arthur M. Harding, Professor of Mathematics, University of Arkansas and George W. Mullins, Associate Professor of Mathematics, Barnard College, Columbia University. Cloth. Pages vii+324. 19x12 cm. 1928. The Macmillan Company, New York.

An Introductory Textbook of Electrical Engineering, by John Robert Benton, Professor of Physics and Electrical Engineering in the University of Florida. Cloth. Pages xi+347. 14x23 cm. 1928. Ginn and Company, Chicago. Price $3.60.

Biology of The Vertebrates by Herbert Eugene Walter, Professor of Biology, Brown University. Cloth. Pages xxv+788. 14x21.5 cm. 1928. The Macmillan Company, New York.

Spherical Harmonics by T. M. MacRobert, M. A., D. Sc., Professor of Mathematics in the University of Glasgow. Cloth. Pages xii+302. 13.5x22 cm. 1927. E. P. Dutton and Company, New York. Price $4.50.

The Rise of Modern Physics by Henry Crew, Ph. D., Professor of Physics in Northwestern University. Cloth. Pages xv+356. 12.5x18.5 cm. 1928. The Williams & Wilkins Company, Baltimore. Price $5.00.

Plane and Solid Analytic Geometry by James McGiffert, Rensselaer Polytechnic Institute, Troy, N. Y. Cloth. Pages xiv+338. 13.5x21.5 cm. 1928. Ginn and Company, Chicago, Ill. Price $2.48.

Modern Solid Geometry by John R. Clark, School of Education, New York University and Arthur S. Otis, Author of Statistical Method in Educational Measurement and Otis Self-Administering tests of Mental Ability. Cloth. Pages xix+461. 13x19 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price $1.20.

Science and Life by Wilbur F. Hoyt, State Teachers College, Peru, Nebraska. Paper. 59 pages. 14.5x22 cm. 1927.

Biology in the Elementary Schools and its contribution to sex Education by Harry Beal Torrey, Ph. D., M. D. Paper. 34 pages. 15x23 cm. 1927. The American Social Hygiene Association, 370 Seventh Avenue, New York, N. Y.

Manual for the Purdue Rating Scale for Instructors by G. C. Brandenburg, Ph. D., Professor of Education and Psychology, Purdue University and H. H. Remmers, Ph. D., Assistant Professor of Education and Psychology, Purdue University. Paper. 31 pages. 11x15 cm. 1p 928. Lafayette Printing Company, Lafayette, Indiana.

Solid Geometry, Problems and Questions by Franklin T. Jones, Third Edition. Paper. 58 pages. 13.5x19 cm. 1928. The University Supply and Book Company, 10109 Wilbur Avenue, S. E., Cleveland, Ohio.

State Laws and Regulations governing Teachers' Certificates by Katherine M. Cook, Chief Division of Rural Education, Bureau of Education. Paper. 296 pages. 14.5x23 cm. United States Government Printing Office, Washington, D. C. Price 40 cents.

Chemistry by Experimentation including Qualitative Analysis, A Laboratory Manual for The First Year Course by Wilbur F. Hoyt, Professor of Chemistry and Head of the Department of Physical Science, State Teachers College, Peru, Nebraska. 25 Illustrations. Paper. 99 pages. 14.5x21.5 cm. 1927. S. W. Hacker, Printer, Peru, Nebraska.

Statistical Methods for Students in Education by Karl J. Holzinger, Associate Professor of Education, The University of Chicago. Cloth. Pages viii+372. 13.5x20.5 cm. 1928. Ginn & Company, 15 Ashburton Place, Boston. Price $3.60.

Plane Trignometry With Tables by N. J. Lennes, Professor of Mathematics, University of Montana and A. S. Merrill, Professor of Mathematics, University of Montana. Pages x+179+92. 15x23.5 cm. 1928. Harper & Brothers, New York. Price $2.20 with tables. $1.60 without tables. Tables $1.20.

Educational Biology by William H. Atwood, Milwaukee State Teachers College and Elwood D. Heiss, Milwaukee State Teachers College. Cloth. Pages xi+469. 14.5x22 cm. 1928. P. Blakiston's Son & Company, 1012 Walnut Street, Philadelphia. Price $2.75.

BOOK REVIEWS.

A First Book in Chemistry, by Robert H. Bradbury, A. M., Ph. D., Head of the Department of Science, South Philadelphia High School. Revised. pp. xii+687. pp. xviii+674+13. 14x19x3.5 cm. Illustrated. Cloth, 1928. Appleton.

This new edition of an excellent text, while maintaining the usual order of events, introduces early in the course the new conception of the structure of atoms and the electronic theory of valence. It utilizes the atomic numbers and makes use of the revelations in regard to the structure of crystals which the x-ray study of them has brought to light.

Much of the material has been completely revised and other parts only slightly modified or left unchanged. The text meets completely all of the requirements of the College Entrance Board, of the Regents of the State of New York and of the syllabus on Standard Minimum Requirements of the Committee of the American Chemical Society.

The book is well balanced as to its presentation of theory, of industrial applications and of the chemistry of the home.

Those who have been using the previous edition will be glad to have this more modern one and many teachers of chemistry will want to see the new edition in order to compare it with other texts. F. B. W.

Beginning Chemistry and its Uses, by Frederick C. Irwin, Head of the Department of Chemistry, The College of the City of Detroit, Michigan, Byron J. Rivett, Principal of the Northwestern High School, Detroit, Mich., and Orrett Tatlock, Assistant Professor of Chemistry, The College of the City of Detroit, Mich. With Drawings by Dorothy Handsaker. 1st Edition. pp. vii+607. 14x19x2.5 cm. Illustrated. Cloth. 1927. Row, Peterson & Co.

The thing that strikes the reviewer on looking through this new high school text in chemistry is the simplicity of the presentation and of the explanations. We teachers of chemistry are probably too prone to assume a mental maturity in our pupils that they are far from having attained. The presentations of this new text do not err in that respect. The illustrations are excellent, especially those of industrial plants.

The teaching of such parts of chemical theory as are presented in the book is beautifully simple. Notable instances of this are found in the presentation of the Avogadro Hypothesis and its use in determining the probable diatomic character of the common elementary gases.

We note the early teaching of valence, which is well, but we miss our electrons, which have helped so much in recent months in explaining the probable mechanism of valence. Probably the authors are following the advice of Polonius "Be not the first by whom the new is tried." Some of us may have to "renig" later on but one can always do so gracefully.

There are good summaries, topics for further study, and exercises for review and application at the ends of the chapters. High school teachers of chemistry should look this new text over. F. B. W.

A Textbook of Bacteriology and Its Applications, by Curtis M. Hilliard, Professor of Biology and Health, Simmons College. Introduction by Samuel C. Prescott, Mass. Inst. of Technology. ix+329 pp. $2.80. Ginn and Company, 15 Ashburton Place, Boston. 1928.

In general, the textbooks of bacteriology deal with the medical aspects of the science. With applications of universal interest, the subject should be popularized to the extent that it will appeal not only to the specialist along biological lines but to the general student who has attained some biological background as well. As a textbook for a course in general bacteriology, this new book is a valuable contribution.

Following a short history of microbiology, the usual basis fundamental to a working knowledge of the subject is laid down. This includes characteristic features of the different groups of microorganisms, classification,

laboratory methods of study and physiological processes of the bacteria. Practical considerations of value in the control of bacteria are taken up in the two chapters on Bacteria and the Physical Environment and Bacteria and the Chemical Environment. Two chapters of special interest to botanists are those on The Fermentation of Carbon Compounds and the Fermentation of Nitrogen Compounds. 68 pages are devoted to bacteriology of water and foods. The Mechanism of Infection and the Theory of Immunity are discussed in two chapters of the text.

There is a chapter on the Respiratory Diseases and another on the Alimentary Diseases which consider pathogenic forms as to effects and methods of control.

The book is not a laboratory manual, however Appendix B and Appendix C give in detail the laboratory technique for the examination of water and for the examination of milk.

This new book should be widely used, not only as a text, but as a reference for those engaged in teaching the biological sciences, nursing, household economics, public health work in various forms and in other branches of social service. Jerome Isenbarger.

Science of Animal Life, by William Morton Barrows, Professor of Zoology, The Ohio State University. x+389pp. World Book Company, Yonkers-on-Hudson, New York and Chicago, Ill. 1927.

The rapid increase in the number of high schools offering courses in general biology and agriculture and the rapid decrease in the number offering special zoology and botany courses seem to point to a demand for something different from some types of zoology and botany courses that have been too prevalent in secondary schools during the past twenty-five years. This new text in zoology is written with the point of view that the study of zoology may be used as an introduction to the study of man. It is intended to be used with an appropriate text dealing with plant life to make up a year's work in biology. There is a difference of opinion as to what should constitute the organizing principle of a year of biology. For those who believe that the work dealing with plant life should be distinct from that dealing with animal life, this text should be an excellent aid in formulating the course. The treatment is ecological and physiological rather than morphological which is as an introductory course should be. The book is well written and appropriately illustrated. It should receive favorable consideration for use in schools offering the type of course for which it is intended. It will be suggestive and a help to zoology teachers in high schools offering a year of zoology.

Jerome Isenbarger.

Senior Mathematics, Book II by Ernst R. Breslich, Assistant Professor of the Teaching of Mathematics, The College of Education and Head of the Department of Mathematics in the University High School, The University of Chicago. Cloth. Pages xvi+296. 13x19.5 cm. 1927. The University of Chicago Press, Chicago, Illinois. Retail price $1.50.

Senior Mathematics is a revision of Professor Breslich's Second Year Mathematics for Secondary Schools. The revision makes definite provision for continuing the mathematics work of three types of ninth year work: (a) a ninth year algebra course, (2) ninth year general mathematics, and (3) junior high school mathematics. The unified plan of mathematics is continued with emphasis on plane geometry but provision is made for review in the operations and laws of arithmetic and for an extension of the algebraic processes and trigonometric ideas previously studied. The inductive method of approach and the arrangement in pedagogical units of instruction are followed throughout the text. The author has retained the devices used in the previous text for creating interest, such as pointing out the utility of the subject by problems drawn from the arts and of science and by the use of numerous historical notes. The many admirers of the previous text will be delighted with the numerous improvements resulting from the years of intensive study of teaching problems made by the author and his colleagues. G. W. W.

New Type Questions in Chemistry by Charles G. Cook, Ph. D., formerly Head of the Chemistry Department, Boys High School, Brooklyn, N. Y. 1st edition. pp. vi+91+a number of specimen examinations. 13x19x 1 cm. Cloth. 1927. $0.80 list. Globe Book Co.

This little book contains numerous sets of questions of the following types—1. The old essay type, 2. True-false type. 3. Completion questions, 4. Evidence questions, 5. Wrong statements to be corrected and 6. Home tests, containing questions that are thought provoking and that require reference work in the text.

The range of topics covered is ample and the questions show that much ingenuity has been used in devising them. F. B. W.

The Story of Chemistry by Floyd L. Darrow, Author of Through Science to God. Illustrated. Cloth. 528 pages. 15x23.5 cm. 1927. The Bobbs-Merrill Company, Indianapolis, Indiana. Price $4.00.

The Story of Chemistry is the gift of a great popular science writer to an intelligent audience. It is written for the rather large body of fairly well read individuals who have not had much chemical education. One cannot open the book without becoming interested at once. It is a true story of the slow development of chemical knowledge from the age of alchemy, thru the struggles of the early chemists in their efforts to separate fact from superstition, to the modern period which has rapidly and almost miraculously changed chaos to system and order. The language used is simple and understandable but not juvenile. Technical terms, mathematical expressions, chemical formulae and symbols are avoided. The method is instruction thru entertainment.

The author does not burden us with a long discourse on the ancient history of chemistry but weaves into history only those parts of the old which are necessary to an understanding and appreciation of the new. The chapter on the electron theory of matter is a valuable contribution to the popular literature on this subject, but the author has committed the rather common but unexcusable error of considering the positive pole of a magnet identical with a positive charge of electricity. The rise and progress of all the various chemical industries are traced almost to the present date, some of the material appearing here for the first time in book form.

The author has drawn freely from current scientific literature such as the Scientific American Industrial and Engineering Chemistry, The Scientific Monthly and many recent books on popular and applied science. It is also evident that he has followed closely the reports of research workers at the many great conventions for promoting scientific investigation. The reviewer considers this book one of the best of popular science books, and a worthy companion of its great predecessors in popular chemistry.

G. W. W.

Molecular Physics by James Arnold Crowther, M. A., Sc. D., F. Inst. P., Professor of Physics in the University of Reading. Fourth Edition with 34 illustrations. Cloth. Pages viii+202. 10x12 cm. 1927. P. Blakiston's Son & Company, 1012 Walnut Street, Philadelphia. Price $2.50.

In a brief chapter of eight pages the author passes over the work of Dalton, Avagadro, Clausius, Maxwell and others, which a few years ago formed the body of the course on the kinetic theory of matter, and has sufficient space left to point out the approximate degree of accuracy necessary to test out by experiment the theory developed. In this manner the classical ideas are used as an introduction to the study of the "new physics" inaugurated by the serious study of the discharge of electricity thru gases and the discovery of radio activity.

The body of the book describes the important experiments used in studying the cathode particles, in measuring the ratio of mass to charge, in positive ray analysis, and in determining the characteristics of the electron. Here also are chapters on the structure of the atom and the relation of the electrons to chemical reactions. A brief statement of the electro-magnetic theory of light as developed by Faraday and Maxwell is

followed by a somewhat more detailed discussion of the quantum theory developed by Bohr. A brief chapter on the actions of molecules in masses, in which attention is directed mainly to the gas laws and conduction of heat and electricity thru matter, and a chapter on the atom in dissolution conclude the book.

The entire treatment is largely non-mathematical but equations are used to show the objectives of the experiments described or to express the results. The author's plan is to describe the experiments which furnished the suggestive ideas for the theories proposed and the experimental evidence produced in testing these theories. For students taking up the study of the electrical theory of matter and for teachers who have not been able to follow closely the recent developments this small volume will be a valuable guide. It is a textbook for study and not a book of the popular science type, and needs to be supplemented by reference reading to be of most value. But those interested in making a brief review of the development of physics in the past thirty years will find the book worthy of attention. G. W. W.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, January, Brooklyn Botanic Garden, Lancaster, Pa., $7.00 a year, 75 cents a copy. Growth and Germination of Sunflowers as Influenced by X-Rays by Edna L. Johnson, University of Colorado, Boulder, Colorado. Further experiments in Repeated Rejuvenations in Hemp and Their bearing on the General by John H. Schaffner.

American Mathematical Monthly, January, Menasha, Wis., $5.00 a year, 60 cents a copy. Mathematics for Students of Chemistry by Farrington Daniels, University of Wisconsin. A Simplification of Certain Problems in Arithmetical Division by Morgan Ward, California Institute of Technology.

Education, February, The Palmer Company, Boston, $4.00 a year, 40 cents a copy. Complete Living as the Goal of Education by Dr. H. H. Horne, School of Education, New York University. A Study of the Basic Information Utilized in Employing Teachers in the United States by Charles K. A. Wang, M. A., University of Chicago. The Lecture Method as a Teaching Device by Joseph I. Pascal.

General Science Quarterly, January, W. G. Whitman, Salem, Mass., $1.50 a year, 40 cents a copy. Status of General Science as Revealed Through State and City Courses of State by Clarence M. Pruitt, Teachers College, Columbia University. Dry-Ice by Howard W. Geisler.

Journal of Chemical Education, February, Rochester, New York, $2.00 a year, 35 cents a copy. The Possible Over-Emphasis of Laboratory Instruction in Higher Institutions by Walter W. Lucasse, University of Pennsylvania, Philadelphia, Pa. Posters in Chemistry by Fannie L. Bell, Ridgewood High School, Ridgewood, New Jersey. More Scientific Education: Less Educational Measurement by Frank B. Wade, Shortridge High School, Indianapolis, Indiana. A Diagnostic Study of Students' Difficulties in Chemistry and the Effects of Application of Remedial Measures by Joseph E. Malin, Swarthmore High School, Swarthmore, Pa.

Journal of Geography, February, A. J. Nystrom and Company, 2240 Calumet Avenue, Chicago, Ill., $2.50 a year, 35 cents a copy. Alaska (A Type of Professionalized Subject Matter), by George J. Miller, State Teachers College, Mankato, Minnesota. New Types of Tests by Madeline F. Goodale, Mary Hemenway School, Boston.

National Geographic Magazine, March, Washington, D. C., $3.50 a year, 50 cents a copy. Michigan, Mistress of the Lakes by Melville Charter. Seeing the World from the Air by Sir Alan J. Cobham.

Photo-Era Magazine, February, Wolfeboro, New Hampshire, $2.50 a year, 25 cents a copy. Astronomical Amateur Photography by Werner Mueller. Random Practical Photographic Notes, by Perry D. Frazer.

Popular Astronomy, February, Northfield, Minnesota, $4.00 a year, 45 cents a copy. Total Eclipse of June 29, 1927, at Jokkmokk by W. J. Luyten. The 30-inch Reflecting Telescope and Photoelectric Photometer of the University of Illinois Observatory by Robert H. Baker.

School Review, February, The University of Chicago Press, Chicago, Ill., $2.50 a year, 30 cents a copy. The Unique Character of American Secondary Education, by Charles H. Judd, University of Chicago. Conditions which Justify Establishing a Junior College by F. P. Obrien, University of Kansas. High School Clubs by R. D. Shouse, Normandy Consolidated School District, St. Louis, Missouri.

Science, Grand Central Terminal, New York City, $6.00 a year, 15 cents a copy. February 10th. Old Problems and A New Technique by Winterton C. Curtis, University of Missouri. February 17th. Wellesley College and the Development of Botanical Education in America by C. Stuart Gager, Brooklyn Botanic Garden.

Scientific American, March, New York, $4.00 a year, 35 cents a copy. Sounds that Burn by R. W. Wood, Professor of Experimental Physics, Johns Hopkins University. Weighing the Earth by Paul R. Heyl, Ph. D., Physicist, United States Bureau of Standards. Unearthing the Past at Kish by D. G. Davies, Director, Field Museum of Natural History, Chicago.

Scientific Monthly, March, The Science Press, New York, $5.00 a year, 50 cents a copy. Internal Secretions in Evolution and Reproduction by Dr. Oscar Riddle, Carnegie Institution of Washington. How it is Done by the Chemist by Professor D. B. Keyes, University of Illinois. The Elements and Safeguards of Scientific Thinking by Professor Elliot R. Downing, University of Chicago.
